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ZINC AND LEAD OCCURRENCES IN PENNSYLVANIA

Robert C. Smith, II

COMMONWEALTH OF PENNSYLVANIA
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Arthur A. Socolow, State Geologist

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PENNSYLVANIA GEOLOGICAL SURVEY

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COVER ILLUSTRATION: Photograph of 1852 lithograph showing the Ecton, "Whim" and "new" Perkiomen mines (left to right, from the east). Courtesy of Allen V. Heyl, U.S. Geological Survey, Denver.

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PREFACE

The purpose of this report is to present a comprehensive, up-to-date summary of the known zinc and lead occurrences in Pennsylvania including an assessment of their economic potential. This report updates B. L. Miller's classic report published by the Bureau of Topographic and Geologic Survey in 1924. During the 50 years since Miller's report, the economics of mining zinc and lead have changed substantially; some rock which in the past had been classified as waste is now considered acceptable ore. Previously unrecovered by-products such as gallium and germanium, are now critical to the electronics industries. Urbanization has encroached on mineralized areas and perhaps unnecessarily increased the United States' dependence on foreign imports. At the same time, expensive construction has occurred over mined-out stopes with total disregard to the dangers involved and without purchasers being informed of their precarious position. Health problems relating to the traces of heavy metals in public drinking water supplies were virtually unknown in 1924, but we now recognize that some zinc-lead mineralized areas are unsuited for reservoirs.

Most important, perhaps, is the need to encourage and support domestic exploration for base metals such as zinc and lead. Pennsylvania's single operating zinc mine at Friedensville keeps the commonwealth on the list of large zinc-producing states, but the country as a whole is increasingly dependent on foreign imports. Greatly improved topographic and geologic base maps of the state, improved stratigraphic correlation, many new man-made exposures, and advances in geochemical exploration methods have made it timely to conduct a more complete and updated inventory of Pennsylvania's zinc-lead occurrences. Recently, an awareness is developing in pollution studies that certain areas are naturally rich in heavy metals without the influence of man; many such areas and formations are indicated in this report.

This report should be of great use to zinc-lead exploration companies, land-use planners, environmental protection agencies, and the property owners themselves. Mineral collectors will also find that some of the occurrences yield brightly-colored or even fluorescent minerals. Historians will note the inclusion of several, previously unavailable maps and references.

ACKNOWLEDGEMENTS

The assistance of the mineral exploration and production industry is gratefully acknowledged as follows: American Smelting and Refining Company, through Jerry N. Biery, released two trace sphalerite occurrences near New Enterprise and furnished old reports on the Milesburg Gap and New Galena prospects. J. E. Baker Company's geologist, L. J. Duersmith, kindly furnished specific locations and samples from the Billmeyer occurrence. The Bethlehem Mines Corporation furnished the services of mining engineer Milton Leet for locating and sampling zinc-lead shows in the Grace Mine; Eastern Industry geologist, Mike Slenker, helped bring the Oley Valley occurrence to the author's attention. The New Jersey Zinc Company furnished assistance from both its exploration and production geologists. Geologists Walter Granlund and A. H. Willman each took time to assist the author with sampling in the active Friedensville area; exploration geologist Charles G. Van Ness furnished the locations of two trace occurrences near Easton and most importantly, has shared the excellent soil geochemical data for the Woodbury prospect (see appendix to Woodbury report with data from Van Ness and Andras M. Schloss), and arranged for the donation of drill core from Woodbury to the Pennsylvania Geological Survey through Dr. F. H. Main, President, The New Jersey Zinc Exploration Company.

Several of Pennsylvania's mineral collectors have contributed specimens and/or locality information. New or lost zinc-lead localities were brought to the author's attention by J. P. Ambler (Claar, Knisley, and Narehood quarries), M. L. Anné (Kline's quarry), Edward Carper (Soister mine), Betty and John Clauser (Edison quarry), Thomas O'Neil (Lime Bluff), Donald Schmerling (York Stone and Supply Co. quarry), and Joseph Varady (Jug Hollow mine). Additional sulfide samples for the descriptions in this report were furnished by Martin Anné (Kline's quarry and Medusa), Bryon Brookmeyer (Blue Ball quarry), George Buchannon (Whim shaft of "new" Perkiomen mine), Betty and John Clauser (Edison quarry and especially New Galena), Thomas O'Neil (a generous selection from Lime Bluff), Donald Schmerling (York Stone and Supply Co. quarry), and Joseph Varady (Ecton, Jug Hollow, and Wheatley mines). In addition, Joseph Varady furnished careful guidance through the perilous Ecton mine, and Jay Lininger and Jim Quickel gave the author a guided tour through the trace-sphalerite occurrences in the York area.

Drs. Jacob Freedman and John W. Price of Franklin and Marshall College provided the location of the Route 324 and mine B occurrences, respectively, at Pequea. Dr. Arthur W. Rose, The Pennsylvania State University, redirected the initial project from a strictly trace-element study to one balanced with the geologic descriptions included in this report. Professor Rose assisted with refinement of the detailed Keystone mine map, and provided an excellent review of the manuscript which detected the most serious shortcomings which have been found. Several of Professor Rose's students have become involved in related theses or other studies and contributed as follows: Dr. David C. Herrick (assistance with Thompson mine location and initial Hares Valley study), Fu-Tzu Hsu (Mount Eagle occurrence), M. Dennis Krohn (prospect northeast of Curtin Gap), Dr. James M. McNeal (initial Hares Valley study), H. W. Schasse (geology of U. S. 22 drill site), and R. L. Schmiermund (Keystone mine area base map).

Donald T. Hoff of the William Penn Memorial Museum assisted with removal of over ten tons of rubble from the mineralized zone at York Stone and Supply Co. quarry and provided data from additional visits he made.

Dr. Allen V. Heyl, of the U. S. Geological Survey, generously shared his extensive knowledge of Pennsylvania's zinc-lead occurrences during the late stages of the report. Information from Dr. Heyl on the "lost" Morris and Napoleon mines arrived too late to include in this report, but will be described in *Pennsylvania Geology* in 1978. Dr. Heyl brought the pre-First Pennsylvania Geological Survey reference on zinc-lead oxides at Mary Ann Furnace, Cumberland County, to the author's attention, and therefore deserves prime credit for locating the Old Clippinger prospect. During the detailed review of this report, Dr. Heyl made numerous marginal notations on the manuscript reflecting his experiences at localities prior to extensive dump high-grading by mineral collectors and based on his general experiences gleaned over years of dealing with zinc-lead deposits in the United States and elsewhere. Where they offer a different interpretation, these comments have been included as personal communications. His comments on the Phoenixville district and the Almedia mine, in particular, are appreciated. The old cross-section maps of the Chester County, Wheatley-Brookdale-Phoenix mines, and "new" Perkiomen mines, the old New Galena plan map, the old Ecton lithograph, and three of the oldest stockholders' reports were made available by Heyl from his personal collection. In summary, the Pennsylvania Geological Survey is grateful to Dr. Heyl for making a major contribution to this report.

The staff of the Pennsylvania Geological Survey has greatly assisted with various geological problems. John H. Barnes and, to a lesser extent, L. T. Chubb, assisted with the earlier X-ray diffraction identification of the minerals; Dr. Rodger T. Faill provided some geologic interpretations and spent a day with the author searching for the lost "Roaring Branch mine"; Dr. Donald M. Hoskins examined some of the Tonoloway occurrences in the Susquehanna River Valley to establish the precise stratigraphy; the late Dr. Davis M. Lapham and, more recently, Bernard J. O'Neill, serving as Chief of the Mineral Resources Division, provided technical review of reports, logistical support, and encouragement; D. B. MacLachlan provided field assistance at Oley Valley and has enlightened the author on the problems of the Beekmantown Group stratigraphy in eastern Pennsylvania; Dr. Samuel I. Root, Chief of the Field Division, provided expert field assistance on complex structures at the Old Clippinger and Woodbury prospects; Dr. Arthur A. Socolow, Director of the Survey, selected and encouraged the initial topic of study and accepted the seemingly interminable delays to the project; Viktoras Skema found the Sugar Hill sphalerite occurrence; and finally, Dr. John H. Way found the Mill Run occurrence, extensively assisted with field work in the Altoona 15′ quadrangle area, and assisted with the difficult mapping of the 80-foot level of the Ecton mine. Several summer field assistants helped with the project: Barrett Borry, M. Dennis Krohn, Jay Parish, Russel Pfeil, and Marc Silverman. Marc Silverman took many photographs including the excellent Doughty and Ecton mine photos.

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ZINC AND LEAD OCCURRENCES IN PENNSYLVANIA

by

Robert C. Smith, II

ABSTRACT

Pennsylvania has potential for the discovery of several economic zinc-lead ore deposits. The most favorable host rocks and areas appear to be: 1) the Lower Ordovician Beekmantown Group carbonates in Berks, Lehigh, and Northampton Counties in eastern Pennsylvania, and Centre, Blair, and Bedford Counties in the central part of the state, 2) the lower Cambrian carbonates in Cumberland, York, and Lancaster Counties, 3) the upper Silurian Tonoloway (hypersaline environment) shaly limestone in Columbia, Montour, Lycoming, Northumberland, Union, and Snyder Counties, 4) the lower Silurian Tuscarora "quartzite" in Huntingdon and Centre Counties.

Relative to the published literature previously available to the exploration industry, a total of about 1 "old", and 3 "new" occurrences are described in Precambrian host rocks, 9 old and 10 new in Cambrian, 14 old and 13 new in Ordovician, 5 old and 16 new in Silurian, 1 old and 1 new in Devonian, 1 new in Pennsylvanian, and 15 old and 2 new in Triassic-age host rocks. Of the previously known prospects, additional prospecting is believed warranted in the Almedia mine, Keystone mine, and Friedensville areas. Of the more recently found, relocated, or described prospects, exploration is believed warranted at the Soister limonite mine, Old Clippinger limonite mine, York Stone and Supply quarry, Woodbury prospect area, and Hares Valley area.

Trace-element analysis of representative limonite ores from Cambrian and Ordovician host rocks appears to be a rapid and accurate method of selecting exploration targets. Arsenic has been found to be widespread in the Valley and Ridge Province, but strictly as trace amounts of sulfosalt minerals. In general, it is probably not present in toxic amounts, but serves to relate the deposits and may be a very useful pathfinder element. Mineral species containing essential arsenic have been found at the Almedia mine, Doughty mine, Lime Bluff quarry, Keystone mine, Hares Valley area, and Millview quarry. Arsenic enrichment is also a characteristic of occurrences at Bamford, Billmeyer, and Friedensville. Fortunately for both exploration and the environment, the arsenic appears to oxidize to insoluble arsenate compounds and is not now known to constitute any hazard.

INTRODUCTION

PREVIOUS STUDIES

Prior to the formal publication of the results of the First Pennsylvania Geological Survey, H. D. Rogers (1840, p. 214) provided information useful for zinc exploration. Unfortunately, at the time there was no zinc exploration, no zinc mining, and indeed, little use for zinc, period. Indeed, in 1860, Dickeson (p. 6) still observed of a shaft at New Galena that:

> From the commencement of the sinking in the shaft, the lode gave a slight admixture of Sulphuret of Zinc or "Blackjack." At a depth of about twenty feet from the surface it almost wholly disappeared, and at the extreme depth of the shaft, the evidences of its existence were so minute, as to afford the assurance, that no difficulty is to be apprehended from this positive enemy to perfect mineral formations.

Dickeson's obvious prejudice against sphalerite became even stronger when later descriptions of the same shaft at New Galena encouragingly reported increasing sphalerite with depth. H. D. Rogers (1858) of the First Pennsylvania Geological Survey was personally committed to the development of a lead-silver mining industry in Pennsylvania, and carefully examined and described the mines of the Phoenixville District. Aside from this one major contribution, however, the two-volume report of the First Survey is almost devoid of reference to lead or zinc.

Publications by the Second Geological Survey of Pennsylvania, from 1874 to 1895, contained major reports on the Sinking Valley and Bamford mine areas, both active intermittently during the period. References were also made to prospects such as the Doughty, Almedia, and Friedensville areas, but with little useful geological description.

The Third (or commissioned) Geological Survey generally limited itself to exceedingly brief summaries which may have actually discouraged rather than aided exploration. Only Jandorff (1912) seems to have considered zinc and lead important. Other subjects apparently deserved a higher priority at the time, and the Broad Top coal field and commodities such as graphite and pigments received excellent treatment.

B. L. Miller's report on *Lead and Zinc Ores in Pennsylvania* published by the Fourth Pennsylvania Geological Survey in 1924 is certainly the high point on zinc-lead reporting to date for the Survey, and one of the most useful single metallic commodity reports ever published by the Survey. It followed district reports published over many years. Miller's report constituted an excellent, complete literature search and he had access to the former Coxe collection of mining reports at Lehigh University. An unpublished mine map of the open pit zinc mines at Friedensville released to Miller by The New Jersey Zinc Company significantly enhanced the report's geological and historical usefulness. Although unacknowledged, the

report also benefited from a number of Lehigh University graduate student theses which Miller supervised. Miller was also able to enter the Chester County mine and see the Phoenixville district prior to extensive ore removal by mineral collectors. Miller's serious shortcomings appear to have been limited to his lack of visitations to occurrences more than about 50 miles from Lehigh University and even some much closer. This problem of very limited field examination is not at all evident when reading the report, but becomes obvious where his description consists largely of quotations from the Second Survey, wherein the occurrence was mislocated substantially by virtue of typographical or other errors, or as at New Galena where one of his students missed the main ore areas and this was not detected. Miller also mistakenly assumed that these occurrences which he did and did not attempt to visit would be easy to find for a long time. This was not the case and many of the locality reference points quoted by Miller from the Second Survey probably no longer existed in 1924.

Following Miller's outstanding compilation there was little immediate need for another major effort on zinc or lead, and indeed, only brief mentions were made in Fourth Survey reports of new occurrences. In 1970, the Survey published a compilation of *Metal Mines and Occurrences in Pennsylvania* by A. W. Rose of The Pennsylvania State University. This concise comprehensive compilation covering all metals included a still more complete search of the Second Survey and other literature including the generally misguided drilling efforts by the U. S. Bureau of Mines in the World War II era. Rose's literature search revealed all but a dozen or so of the most obscure references on zinc and lead in Pennsylvania, and included brief summaries of the literature for the major occurrences, a scientific, but practical, classification system, and a selection of the more important references for reconnaissance purposes. Although it intentionally included no additional field work, it served as a sound base for the present report.

As noted, the U. S. Bureau of Mines exploration of the 1940's and early 1950's did not serve the mining industry well. With the exception of the well-done report on the Correll mine, drilling seems to have begun before the old mine reports were read, old prospects located, strike and dip of the vein determined, etc. Economic necessity at the time of drilling also seems to have resulted in the assumption that none of the drill holes deviated from their intended course. As a result, separate calculations by the author and A. V. Heyl of the U. S. Geological Survey suggest that many of the drill holes fell slightly short of even their intended targets. Unlike the selection of drilling targets, the logging of the cores by the U. S. Geological Survey seems to have been excellent.

Moebs and Hoy's 1959 paper on the structure of northern Sinking Valley showed the contribution that industry can make to the geology of a mineralized area, and W. H. Callahan's (1973) paper on the nationally important Friedensville deposit, in the author's opinion, is one of the best descriptions ever published of an ore deposit in Pennsylvania. It is hoped that economic conditions and environmental attitudes will permit an industrially-sponsored update report as mining and reserves advance. To the best of the author's knowledge, Friedensville is one of the most important mining properties in the commonwealth and, perhaps in the entire Appalachians. As such, the area needs protection from developers, promoters, and others who would restrict access to one of the region's major mineral prospects.

PRESENT STUDY

The present study traces its origin to the author's curiosity about zinc-lead occurrences in central Pennsylvania while a resident of that area (Smith and others, 1971). Upon joining the Pennsylvania Geological Survey in April 1972, a project proposal dealing with zinc and lead in Pennsylvania was selected by the Director of the Pennsylvania Geological Survey, Dr. Arthur A. Socolow, from six submitted by the author. Thus, when asked how soon the project could be begun, the author was able to reply, half seriously, half in jest, that it already had! As originally planned, the project was to have consisted of properly locating each of the occurrences mentioned in Miller (1924) and Rose (1970), and collecting sulfide samples for in-house trace-element analyses. These analyses were to identify potential by-products, as well as environmental health problems, and perhaps to classify deposits for exploration or determine if additional elements were useful clues to their presence. The report was and is not intended to be historical or to deal with the theoretical genesis of the deposits. A few weeks after actually beginning the project, the Agnes flood of June 1972 almost totally destroyed the Pennsylvania Survey's laboratories, economic collections, and general headquarters. After extended salvage operations and three assignments to temporary headquarters, it became apparent that the Survey would not have suitable laboratories operable until 1976. A series of informal consultations with the Director of the Survey established that the trace-element phase should be postponed and that complete, detailed, relevant geological information on each occurrence should be obtained and brought forth as soon as possible. The Director's decision was also encouraged by a review of the original proposal by Professor A. W. Rose and by a few exploration geologists whom the author contacted for suggestions as to what would be most useful in such a commodity study. With the goal redefined, the report format was carefully established by the author, his Division Chief (the late Dr. Davis M. Lapham) and the Director, and was carefully followed. Thus, the

present report attempts to be descriptive and to avoid genetic discussion and history except where the author was privileged to make a unique observation which could influence the course of exploration.

In total, the present report is the result of 4 man-months of field work (mostly 1973-1974), 4 months of literature search (mostly 1972-1973), and over 12 months of writing and report preparation (mostly 1974 and 1976). Field work was done mostly as one- to three-12 hour days at a time, because of the scattered nature of the occurrences, necessity of extensive pre-field preparation (by use of air photos, etc.), and the way in which previous observations led to the discovery of new, related occurrences. In many cases, travel and finding the occurrence required most of the field time. Some occurrences took several days of pre-field preparation, a total of one day of driving, two days of continuous hiking, and only two hours for the description of limited outcrops and dumps. Mines said, in the literature, to be totally inaccessible were found to offer hope of underground sampling and mapping. It was necessary to return to these at a later date because one of the following was needed: highly-specialized equipment, a photographer, reliable notification of anticipated return, departure of non-dormant animals in the entrance, subsidence of water levels, or freezing of surface soils deep enough to provide roof support for re-excavation. Several of the mines were judged unsafe in areas. For these, the photographic and the written record is especially detailed to decrease the necessity of future geologists having to enter them. In the author's opinion (although he is not trained as an engineer), several of the mines will sustain significant cave-in, in the next decade. This will result largely from deterioration of stope platforms, roof supports, and cribbing made of timbers exposed to damp air for 100 years. Only the centers of the thickest timbers are solid.

In addition to visiting known occurrences, a total of a few weeks near the end of the project was spent in testing a few exploration methods: 1) examining good exposures of stratigraphic horizons believed to be favorable to zinc mineralization based on the previous field work. This technique verified that the upper Bellefonte Formation of Blair County was favorable for localization of at least trace to minor occurrences of sphalerite. 2) sampling limonite ores for trace-element analysis. This technique located the Soister, Carper, Old Clippinger, Oley Valley, and Ironton[1] prospect areas. 3) sampling soils for geochemical analyses near known prospects with poor outcrop. This technique, only briefly used, established a trend for mineralization at the Old Clippinger prospect (assuming two points determine a trend!) and Roaring Springs prospect. 4) stream sedi-

1. The Ironton area prospect was subsequently found to have been discovered earlier by The New Jersey Zinc Company. Ironton residents reported that the prospect was drilled, and following this, attempts to purchase the property were said to have been made. The drilling, but not the land acquisition attempts, have been verified.

ment sampling for geochemical analyses was used in the Woodbury prospect on a detailed spacing. Here, the technique resulted in the discovery of a sphalerite-mineralized outcrop at each of the four unexplained anomalies. Less detailed sampling in southern Blair County produced no real anomalies that would have indicated previously unknown zinc or lead. Similarly, a brief geochemical reconnaissance of Mountain Creek produced ambiguous results. 5) stream sediment sampling to verify previously reported zinc anomalies. These were reported by Keith and others (1967) and Rose and Keith (1971). Zinc anomaly numbers 16, 127, 136, 168, 259, 508, 651, 1172, and 1193 of the latter report were found to be irreproducible when sampled under favorable conditions, and further follow-up was terminated. Personal communication with Rose (1975) revealed a problem with the emission spectrometer procedure used to determine zinc prior to Rose's joining the project. Similarly, much of Keith's sampling was unavoidably conducted during an extended drought, during which time metals may have been derived from deeper sources than at any time since. Despite these problems, the drainage cell anomalies (rather than single site anomalies) may be worth rechecking, because of the speed and low cost involved. Drainage cells 120 and 121 of Rose and Keith (1971) were recognized in 1976 as having geology favorable for mineralization, and were sampled. The present results confirm the analyses of Rose and Keith (1971), and are favorable. This anomaly will be further discussed in *Pennsylvania Geology* during 1978.

Because it was anticipated that the present report would have to be set aside for priority work (six man-months for four moves, three months for diabase mapping, nine months for General Geology Report 33 *Mineral Collecting in Pennsylvania,* and 15 months for service work to industry, academia, government, and the general public), the author and Survey Director Socolow agreed to publicly announce and open file (Pa. Geol. Survey No. 16) reports covering portions of central Pennsylvania in 1974. Industrial response was both substantial and rapid. As a direct result of the open file, two areas were leased and explored. The first, by The New Jersey Zinc Company, yielded "inconclusive results" (F. H. Main, personal commun. to A. A. Socolow, 1975), but resulted in the geological information and geochemical soil data by C. Van Ness included in the present report. This was pursued with a sensibly balanced program, but was never fully tested because of extremely complex geology which also baffles the Pennsylvania Survey. The second prospect remains active and a third, an indirect result of the open file, is just beginning. Response to the open file also favorably confirmed the format of the present report.

The present study also led indirectly to industrial examination of the Oley Valley (Manwiller limonite) and York Stone and Supply prospects. Both are active quarries, and their staff chose not to wait for the Pennsylvania Survey to publish a final report. The Oley Valley quarry's geologist

chose on his own to contact The New Jersey Zinc Company.[2] Limited deep drilling was begun, but the stratigraphy and structure were rumored to be complex. The York Stone and Supply quarry chose to have their consultants pursue the prospect.

FORMAT OF PRESENT CHAPTERS

Some comments of the format and content of the present chapters within this book are necessary. First, the prospects are arranged primarily by host rock, the factor found to have the greatest influence on the occurrence. Specifically, the occurrences are listed by geologic era of the host rock, beginning with the oldest and within that classification, generally grouped by formation where the similarities and number of occurrences warrant. Lastly, prospects are arranged alphabetically within an era or formation. In some cases, as at Friedensville or Phoenixville, this has resulted in splitting occurrences within a district. A strong preference for this organization for major prospects or those with distinct histories was expressed by the industrial users of the open file. For those not so oriented: A) Plate 1, the location map, contains numbers keyed to the individual descriptions, B) the title of each report identifies the county, C) the reports and Table of Contents identify the "district" to which a prospect belongs, and D) copious use of synonyms and cross-references has been made in the index.

In several cases, the author visited, described and sampled occurrences with little or no economic potential. When these were in the same host rock as significant occurrences, the description was shortened, but included as a separate chapter. In cases where the occurrence is in a highly unfavorable host and not likely related to nearby occurrences, the description has been condensed into an entry into the table summarizing lost and trace occurrences (see Table 2, Appendix I).

1. *Name:* This includes the most appropriate name for a prospect and has used established names (such as mine A, B, and C at Pequea) where possible. In a few cases (such as vertical shaft at Pequea) obvious features, locally accepted names, or local geographic features have been used. In complex areas where the author found numerous new occurrences, letters or numbers or simple names have been assigned within a district so as to avoid confusion with adjacent districts. Thus, the Hares Valley report describes prospects 1 through 14, the Woodbury report describes prospects a through j, and the southern Sinking Valley report uses old prospect names such as Albright, Fleck, Isett, etc. This is a case of choosing clarity over consistency. In many cases a given prospect was given a new name by each promoter, stock issue, or company in order to dim the memory of past

2. At the time, two other reputable companies were independently pursuing geochemical anomalies in Oley Valley, but the author was bound not to relay information in any direction. Apparently, for reasons of secrecy, the geochemical exploration groups never sought to examine the nearby quarry which contains conspicuous sphalerite!

failures. Thus, one mine may have several names listed, with the most generally accepted one first. Another problem, especially in the Phoenixville, Ecton, and Sinking Valley districts was the working of several mines by one company. Thus, the terms Wheatley, Perkiomen, and Keystone mines have been almost universally misused. The confusion is readily understood when one considers how a company may have switched mines or purchased, leased, or obtained ore from other mines. Finally, a few previous, otherwise good, studies have associated the wrong prospect with the wrong description in the Second Survey. Zeller (1949) and Reed (1949a) have done this for several prospects in southern Sinking Valley. Fortunately, the author obtained a copy of a property map for the period (Nickols, 1873) in question, and a few residents kindly searched copies of their deeds back to Indian ownership! Even so, a few of the old prospects near Culp are of uncertain identity, as will be noted.

Where known, the owner of an occurrence has been listed. *None of these have been verified* by searching of courthouse records. Therefore, some could be wrong or the mineral rights separately held.

2. *Location:* This includes A) a verbal description to permanent topographic features or semi-permanent structures. Some of the reference points will, of course, be lost or will change with time. B) The latitude and longitude given to the nearest second. Most prospects have been very carefully located on topographic maps by pacing, tape and compass, triangulation, or air photo study. Thus, most of the locations visited after the Agnes flood of June 1972 should be accurate to ±100 feet with only a few inaccurate by ±200 feet. A few of the users of Open File 16 have proudly but sadistically reported that they have attempted to disguise, conceal, or remove a few critical outcrops. The Survey has established a reference collection because of this problem, and will attempt to help the victims of these practices. C) The $7\frac{1}{2}$-minute topographic quadrangle name. In addition, location maps are included for several of the complex areas and previously incorrectly located prospects.

3. *Host Rock:* Where known, this includes the presently accepted group, formation, and member names, distance to contacts, and general lithology. The staff of the Pennsylvania Survey have assisted in updating archaic formational names.

4. *Estimated Total Amounts of Ore Metals:* This entry includes: A) an order of magnitude estimate of the metals, and B) assays, where available. The order of magnitude estimates of the amounts are just that, estimates, and *will frequently be in error* by an order of magnitude. They are *not* an accurate measure of reserves. Generally, they are an estimate of the amount of metals present as discrete sulfides which could be collected using hand tools. Where there is some evidence for continuation in a third dimension, the estimate is calculated on the assumptions listed for that

occurrence. In most cases, the author's estimates fell between those of the reviewers, A. V. Heyl (much higher) and A. W. Rose (somewhat lower). Where their opinions differ substantially, they have been included. Even with the probable gross errors made by the author, industrial response indicates strong preference for this type of estimate. The assays are generally from old stock reports on high-graded samples submitted to the Second Pennsylvania Geological Survey's laboratory under McCreath. By modern standards, even the honestly collected samples must be considered to have been high-graded by selective mining. In many cases, the author has commented on the reliability of the old assays. Modern trace-element analyses done by the U. S. Geological Survey, on the other hand, are generally as accurate as the method employed.

5. *Minerals Observed and Relative Amounts:* Here, the "introduced" (vs. host rock) minerals have been grouped into a potential economic category and a probable gangue category, and divided into major, minor, and trace amounts within those categories. Inclusion within the economic category does not necessarily mean that a given mineral could be profitably recovered for its metal value if the deposit were to be mined. Some are only present as a few grams and metallurgical problems have not been considered. An asterisk (*) following a mineral indicates that a mineral's identification has been at least partially confirmed by X-ray diffraction. In most cases, other published mineral lists are inaccurate, and they have not been included. Exceptions include a few minerals identified by Drs. Arthur Montgomery or A. V. Heyl. As indicated by the title of the section, only the presently *observed* minerals are listed, and the amounts are *relative*. Thus, 1,000 tons of hemimorphite would be a major amount for the small Doughty mine, but a minor mineral for the Ueberroth mine at Friedensville.

6. *Paragenesis:* If determined from hand specimen, the paragenesis is given from oldest to youngest. A comma has been used to separate minerals within a process and a semi-colon to separate minerals which appear to have formed in separated stages or by separate processes. Almost all of the parageneses reported are *uncertain*, especially where noted. In almost all cases, they are derived from hand specimen or sawn slab examination. Because most occurrences yielded only dump specimens, the paragenesis reported may not accurately reflect the entire occurrence. For most occurrences, however, the entire sample for trace-element analysis was examined to determine the paragenesis. Key specimens with successive crustifications have been saved in the economic collections of the Pennsylvania Survey.

7. *Geologic Description:* This includes a description of the major structures, attitude of bedding, apparent geometry and locus of mineralization, textures, and where possibly relevant, information on joints, reducing

materials, porosity, etc. Most bedding data is the median of three or more determinations. The best numerical estimate (median) of strike is presented alongside the strike and dip symbol as well as the traditionally reported dip value. Available information on old mine workings is summarized and clarified in several cases with mine maps. Generous use has been made of photographs, and pace or tape and compass maps prepared of the actual prospects. Where warranted, the geologic description closes with an estimate of the economic potential.

The bibliography following the descriptive portion of the report includes all useful references on zinc and lead in Pennsylvania which have been found by the author.

Finally, the reader should be cautioned that each of the occurrences was examined for only a few days at most, that the abundance estimates are usually based on two dimensional data with only a guess at the third, and that much data were collected under unfavorable conditions. Thus, a detailed study of any of the areas should be able to improve upon the present reports, and errors will certainly be found.

FUTURE STUDIES

As noted, the project was originally intended to consist of trace-element analyses of pure sulfide concentrates. The required samples have been collected and preliminary concentrates prepared by hand picking, gold-panning, and heavy-liquid separations with acetylene tetrabromide and methylene iodide. Following magnetic separation, Clerici heavy-liquid separation, and hand picking, the pure concentrates will be analyzed for selected minor and trace elements as Ag, As, Cd, Ga, Mn, Ni, etc., by X-ray fluorescence and atomic absorption. Attempts will be made to interpret this data in terms of economic recovery, pathfinder elements for geochemical exploration, potential natural environmental problems, and the classification, zoning, and genesis of the occurrences. Following interpretation of the trace-element data, the economic evaluations presented in this report will be further quantified. At the suggestion of the exploration industry, thin sections from the larger sphalerite occurrences will also be briefly described. This may result in refinement of the paragenetic data in this report, and will certainly result in more accurate sphalerite color descriptions.

As part of the zinc-lead project, a collection of representative samples was established. In some cases, small samples may be made available to qualified researchers for isotopic, fluid inclusion, or other studies. Similarly, small splits of the heavy-liquid sulfide concentrates may be made available for neutron activation, vapor atomic absorption, emission spectrographic, and other analytical methods not covered in the present study.

PRECAMBRIAN OCCURRENCES

1. CHESTNUT HILL QUARRIES, NORTHAMPTON COUNTY

(Trace Zinc Occurrences)

1. *Name:* a) Quarry L of Peck (1911) owned by Pfizer, Inc., Pigments and Metals Division; b) Schweyer's quarry; and c) C. K. William's quarry.

2. *Location:* A. a) Quarry L is located on the west side of the gap of Bushkill Creek through Chestnut Hill. The quarry is at an elevation of about 290 feet (88 m), and is just west of Lehigh Valley Railroad at a point 2000 feet (600 m) N18W of the 13th Street exit of U. S. Route 22. This quarry is about 200 feet (60 m) east of the Wilson Boro-Easton city boundary and 1.50 miles (2.4 km) N79W of the junction of Bushkill Creek with Delaware River. b) Schweyer's quarry is located on the east side of the gap of Bushkill Creek through Chestnut Hill, Easton. The quarry is just northeast of Bushkill Drive, about 1000 feet (300 m) northwest of the intersection with Lafayette Street, within the Easton city limits. c) William's quarry is located in Forks Township along U. S. Route 611, 1.3 miles (2.1 km) north-northeast of the junction of the Delaware River and Bushkill Creek. All three quarries are in Northampton County.

B.

	Quarry L	Schweyer's	William's
LATITUDE N	40° 42′00″	40° 42′02″	40° 42′47″
LONGITUDE W	75° 13′59″	75° 13′52″	75° 11′48″

C. TOPOGRAPHIC MAP: Easton 7½-minute quadrangle.

3. *Host Rock:* Precambrian Franklin marble which has been metamorphosed to serpentine minerals, tremolite, and phlogopite. Peck (1911, p. 21) describes the zone at Schweyer's quarry which probably yielded the sphalerite-bearing float observed during the present study as "Ten feet of fine, even, granular pearl-gray to white tremolite mixed with more or less calcite or dolomite, or consisting largely of these two carbonates." The matrix of the disseminated yellow sphalerite at Schweyer's quarry is a calcite marble. The host to the zinc-lead sulfides at William's was marble.

4. *Estimated Amounts of Ore Metals:*

A.

	Quarry L	Schweyer's	William's
<1 g:			
1-1000 g:	Pb, Cu		Pb
1-1000 kg:	U, Th	Zn (probably less than 10 kg)	Cu, Mo,[1] Zn (probably less than 10 kg)
>1000 kg:			

1. Mo is not directly associated with Zn or Pb. Farther north in the quarry, molybdenite was at one time more abundant.

B. *Assays:* A 3-foot- (1 m) long "channel" sample (continuous line of chips, but of varying size; sample weight about 12 pounds or 5 kg) from Quarry L collected through a 15-foot- (5 m) long radioactive zone was assayed and found to contain 0.1% U_3O_8. This zone has an average gamma activity of about 0.5 mR/hr, and consists of a lean dissemination of uranium-thorium oxides in phlogopite with serpentine group minerals. A 48-inch (1.2 m) channel sample through another portion of the zone was found to contain .050% eU, .039% eTh, and 1.9% eK[2] (Richard I. Grauch, U. S. Geological Survey, personal commun., 1975), 0.036% uranium by chemical assay, 31 ppm As, 40 ppm Pb, and 400 ppm Zn (William L. Chenoweth, E.R.D.A., personal commun. 1976).

A visual estimate of the richer hand samples of sphalerite in marble from Schweyer's quarry suggests about 0.5-1% Zn.

5. *Minerals Observed and Relative Amounts:*

	Quarry L	*Schweyer's*[3]	*William's*[4]
A. ECONOMIC			
Major:			
Minor:	Thorian uraninite, thorogummite (pale-yellow), and wolsendorfite(?)		Thorian uraninite[5]
Trace:	Chalcopyrite, galena, sphalerite(?), and malachite	Sphalerite (mostly lemon-yellow, but ranges from colorless to dark-red-brown), thorian uraninite	Chalcopyrite, molybdenite,[6] sphalerite (lemon-yellow), galena, malachite, chalcocite(?),[7] wulfenite[7]
B. GANGUE			
Major:	Serpentine group, tremolite, phlogopite	Tremolite, phlogopite	Calcite (white)
Minor:	Talc, calcite, dolomite	Calcite (pink to gray), pyrite (cubes)	Pyrite, phlogopite, talc, quartz, calcite (orange, strontian),[7] barite (white, platy), celestine (clear, platy)

2. eU, eTh, and eK are the equivalent metal contents assuming isotopic equilibrium. They are radiometric determinations, and are frequently somewhat in error.

Trace:	Zircon (zoned crystals up to 5 mm)

6. *Paragenesis:* a) Quarry L: Unknown, but the galena and chalcopyrite occur in veins which cut across the serpentine-tremolite relict beds. b) Schweyer's: The lemon-yellow sphalerite commonly contains relatively large pyrite cubes, suggesting that sphalerite is younger than pyrite. c) William's: Montgomery (1957, p. 808) notes that sphalerite and galena formed at about the same time as molybdenite and pyrite, and after the thorian uraninite. A. V. Heyl (personal commun., 1976) never saw molybdenite or the uranium-thorium minerals associated with lead-zinc when the quarry was active. Heyl suggests that the zinc-lead may belong to an unrelated, late phase. The zinc-lead association occurred in calcite veins cutting across the marble and serpentine.

7. *Geologic Description:* These three occurrences in Franklin marble are located in the structurally complex Chestnut Hill within the overturned rocks of the Easton $7\frac{1}{2}$-minute quadrangle. Chestnut Hill is reported to be bounded by the Musconetong fault which separates the metamorphosed Franklin marble and crystalline rocks of the nappe core from Cambrian Leithsville dolomite (Drake, 1967). Based on the mapping of Drake (1967), Chestnut Hill is underlain by the overturned, lower limb of the nappe. Following development of the Musconetong fault and folding in the nappe core, Chestnut Hill was probably offset by a left-lateral cross fault through Bushkill Gap. Miller (1939) and other geologists offer different structural interpretations.

Drake's map shows the area of serpentine in which quarry L is located as potassic feldspar gneiss. When the quarry area is correctly mapped as marble and its alteration products, the apparent offset on the cross fault through Bushkill Gap is substantially decreased.

Although thoroughly metamorphosed, the compositional bedding of the Franklin Formation is N85E, 42S. Crosscutting veins of tremolite and talc with trace chalcopyrite and galena trend N37E, 45NW and N52E, 72NW. The veins are about 0.5 to 2 inches (1 to 5 cm) wide with the fibrous minerals perpendicular to vein walls. Figure 1, a schematic plan map of the quarry, shows the location of these veins.

Radioactive zones are irregularly distributed, but generally in phlogopitic host rock. The largest known zones occur at the base of the west

3. Elsewhere in Schweyer's quarry many other minerals can be found: epidote, grossular(?) garnet, etc.
4. Montgomery (1957) presents a nearly complete mineral list for William's quarry.
5. Not found directly with sphalerite and galena.
6. Molybdenite was found with chalcopyrite as a lean dissemination in marble in the same area as the sphalerite. Molybdenite and sphalerite have not, however, been found directly associated.
7. Reported by A. V. Heyl (personal commun., 1976).

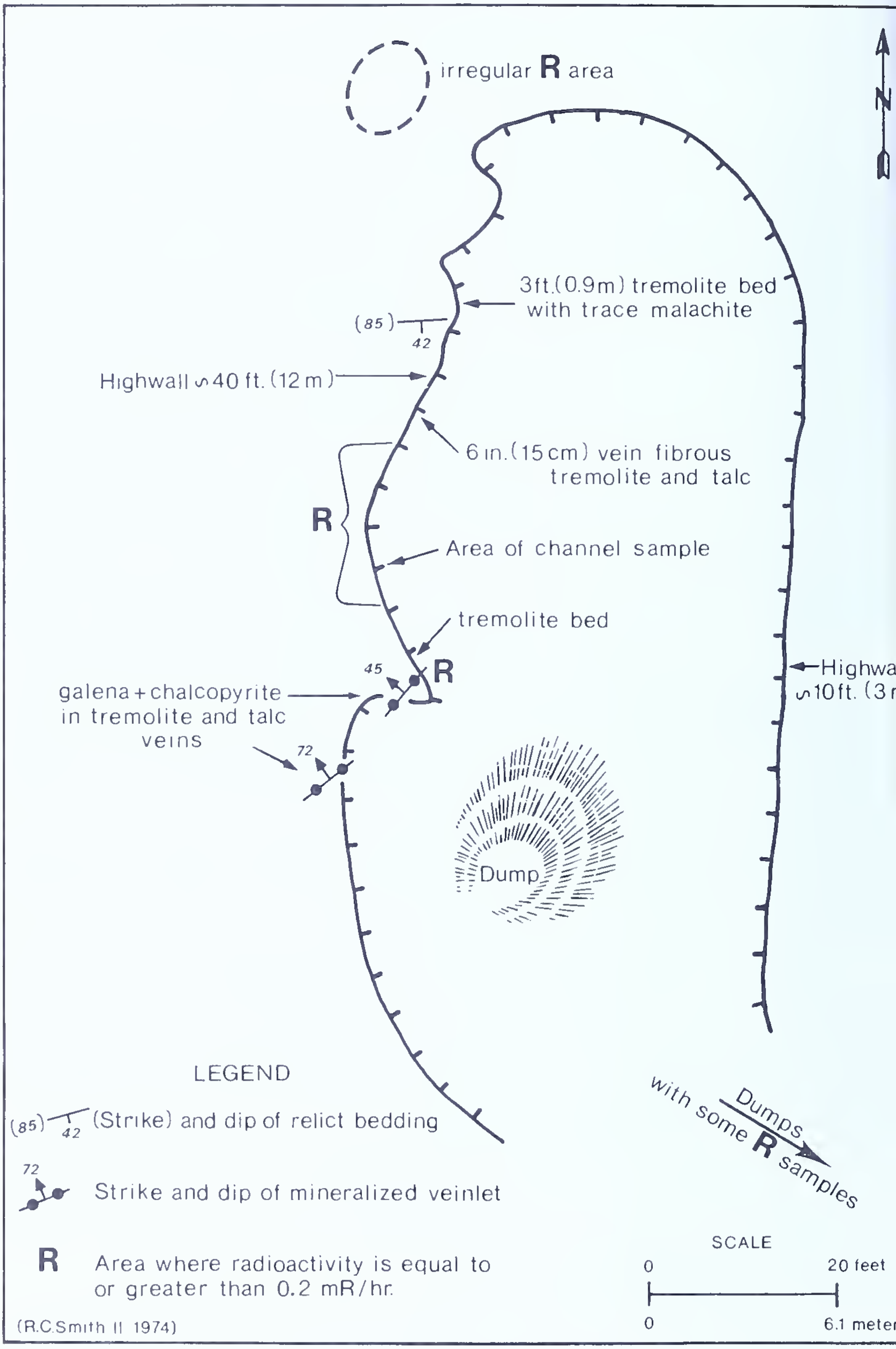


Figure 1. Quarry L workings and geology, Easton, Northampton Co.

face and just above the northwest corner of the quarry. The most radioactive part of the dump is located southeast of the quarry, overlooking the railroad. The small quantities of galena observed relative to the abundance of uranium-thorium minerals suggest that some of the lead could be of radiogenic origin.

A quarry between Franklin and Byram rocks about 775 feet (235 m) east of the west end of the road in Hacketts Park and just south of the crest of the hill contains brick-red, radioactive thorite(?) grains up to 4 mm (0.15 inch) in skarn float. Continuing east on the crest, felsic gneiss with a 0.07 mR/hr background is encountered where a power line crosses the hill. Following the power line downhill towards Pfizer's, and then northeast for about 75 feet (23 m), a small quarry with fair quality talc schist has an activity up to 0.15 mR/hr in the south wall.

The disseminated sphalerite in marble at Schweyer's quarry was apparently part of a 10-foot- (3 m) thick calcareous tremolite lens. Metamorphism of this lens and surrounding serpentinites and skarns was probably accomplished by intrusion of alaskites and pegmatites during late Precambrian as well as regional metamorphism earlier during the Precambrian.

Peck (1911, p. 20) states that beds in the Schweyer quarry strike N55-62E and dip 55-65S. The present author determined the long axis of the quarry to be N55E. The different beds described by Peck are probably based on original sedimentary composition. This so-called bedding probably has little stratigraphic meaning. Drake (1967) indicates potassic feldspar gneiss at depth.

Galena was early noted from the William's quarry (also known as the Verdolite quarry, Sherrer quarry, etc., excluding adjacent quarries as Fox, etc.) by Eyerman (1904, p. 45). Sphalerite in the general area was briefly noted by Miller (1939, p. 439) and by Jewell Glass (Bayley, 1941, p. 37) from the William's quarry proper. Sphalerite from William's quarry collected by the author during the mid-1950's occurred as lemon-yellow blebs up to 2 cm with pyrite in marble. This area is located about 300 feet (90 m) southeast of the north wall. As noted, the mineralogy of this interesting quarry has been described in detail by Montgomery (1957).

It is believed that the sphalerite at Schweyer's and William's quarries is genetically unrelated to the zircon, uraninite, and molybdenite. Sphalerite is a common accessory in Franklin marble at several places where these other minerals are rare: Franklin, Sterling Hill, Lime Crest, Andover, and Buttzville.[8,9] Because sphalerite is a common accessory in Franklin marble over a large area, the author assumes that the zinc is of metasedi-

8. At Buttzville, about 12 miles (19 km) northeast of Easton, Bayley (1941, p. 88) notes that 200 tons of 12% zinc were produced in addition to a few tons of 50% zinc, hand-picked from the waste rock.
9. Boynton and others (1966), however, detected other radioactive areas in the Franklin marble.

mentary origin. The wide distribution and occasional large concentrations of zinc suggest that the Franklin Formation should be carefully prospected for zinc. Conceivably, the sphalerite in the Cambrian Leithsville dolomite about 600 feet (180 m) southeast of Schweyer's quarry could have been remobilized during tectonically associated hydrothermal activity from a Franklin Formation deposit beneath. Areas of epidote-grossular skarn along Applebutter Road between Hellertown and Easton and a possible sphalerite occurrence "nearly a mile north of Shimersville. . ." (Prime, 1878, p. 5) should similarly be checked. Geochemical soil sampling is recommended over all areas of the outcrop-lean Franklin. Because of its weathering characteristics, several areas of marble have been missed on early geologic maps.

It has been rumored that the Rattlesnake Hill drill hole, 8.1 miles (13 km) south of the square in Easton, was substantially mineralized with copper and zinc. Emission spectographic analyses show that the best intercepts were 6 inches (15 cm) or less of 50 ppm Cu with Zn not detected (A. A. Drake and J. Epstein, personal commun., 1973)! The only anomalous intercept was from 230-240 feet (70-74 m) which contained 0.12 ppm Au. A. V. Heyl (personal commun., 1976), who logged the hole in 1968, confirms that it was barren of visible copper or zinc sulfides.

It is gratefully acknowledged that the Schweyer quarry zinc occurrence was brought to our attention by Mr. Charles Van Ness of The New Jersey Zinc Company.

2. COATESVILLE PROSPECT, CHESTER COUNTY

(Massive Sulfide Prospect With Trace Copper-Zinc)

1. *Name:* The Coatesville prospect or pyrrhotite adit.

2. *Location:* A. The Coatesville prospect is located between U. S. Route 30 and an unnamed tributary to Rock Run, Valley Township, Chester County. The pyrrhotite adit is about 300 feet (90 m) south of U. S. 30 and about 150 feet (45 m) northwest of the northeast-flowing creek. This is 0.9 mile (1.4 km) west-northwest of the complex intersection at Rock Run, 0.8 mile (1.3 km) northwest of Hayti, and 1.45 miles (2.15 km) northwest of Business Route U. S. 30 over West Branch Brandywine Creek in Coatesville. The adit is on the southeast-facing side of a hill at an elevation of about 500 feet (150 m).

B. LATITUDE N: 39° 50′ 38″ LONGITUDE W: 75° 50′ 50″

C. TOPOGRAPHIC MAP: Coatesville 7½-minute quadrangle.

3. *Host Rock:* Muscovite schist between Precambrian Baltimore granitic gneiss and "gabbro" of early Paleozoic or late Precambrian age (Bascom and Stose, 1932). In reality, the "gabbro" may be a basic metamorphic rock.

4. *Estimated Amounts of Ore Metals:*[1]

A. <1 g:

1-1000 g: Ag

1-1000 kg: Cu, Ni

>1000 kg: Zn

B. *Assays:* A sample consisting of 25 two-inch (5-cm) pieces of fresh sulfides in schist was found to contain 38 ppm Co, 395 Ni, 415 Cu, 1250 Zn, 17 As, 0.2 Ag, and 39 Pb. Of those, only Zn, Cu, and Ni are somewhat high compared to common metamorphic rocks. R. Weiss (circa 1964) reported a semi-quantitative emission spectrographic analysis of a composite of several, typical specimens as follows: Ni 100 ppm, Co N. D., Cu 1000, Zn 10,000, Pb 30, Mo 30. The determination of zinc in high-iron samples by emission spectroscopy is, however, difficult and semi-quantitative commercial analyses are subject to large errors. A fire assay supported by the Mineral Conservation Section at The Pennsylvania State University showed Au N.D., and Ag 5 ppm.

5. *Minerals Observed and Relative Amounts:*

A. ECONOMIC

Major:

Minor:

Trace: Chalcopyrite, sphalerite,[2] magnetite, millerite(?)[2]

B. GANGUE

Major: Pyrrhotite (monoclinic?, moderately magnetic), pyrite (some as cubes in pyrrhotite), muscovite, quartz

Minor: Dolomite (ferroan)[3]

Trace: Graphite, dravite[4] (golden-brown prisms)

6. *Paragenesis:* R. Weiss (circa 1964) reported: graphite, magnetite, pyrite, pyrrhotite, millerite(?), chalcopyrite and sphalerite.

7. *Geologic Description:* R. Weiss, former economic geologist at the Pennsylvania Geological Survey, described the occurrence as follows:

> The metallized material occurs within a narrow east-west-trending zone which apparently delineates a small part of the contact between an early Precambrian gabbroic gneiss and a late Precambrian granite gneiss. This zone, which extends to over 100 feet in width, has apparently undergone such intense silicification and sericitization that the only identifiable rock minerals present are primary and secondary quartz and sericite. Metallic minerals per-

1. Based on a guess of 1000 tons of mineralized rock, but this could be in error by an order of magnitude.
2. Reported by R. Weiss (circa 1964) in polished sections.
3. X-ray diffraction verification by J. H. Barnes, but all records were destroyed, and this could have been ankerite. The present Joint Committee Powder Diffraction Standard ankerite pattern is actually an erroneously-listed ferroan dolomite.
4. Verified by determination of optical properties.

meate through 40 to 60 feet of the zone, and impart a dark-bronze color to the otherwise bleached rock. Metallization is bordered on the north by gabbroic gneiss and on the south by bleached quartz-sericite rock. Only the south boundary can be physically observed, and this is very sharp.

The adit is 10-15 feet (3-5 m) wide and 43 feet (13 m) long with two, irregular raises in the unstable roof, which is estimated to vary from 8 to 20 feet (2-6 m) high. The adit itself trends about N12W,[5] and in the back of the adit the "ore" trends N25 ± 10W with a thickness of about 10 feet (3 m) from the floor to the roof. About 200 feet (60 m) N70E[5] from the entrance there is a sulfide gossan outcrop (observed after a local flood) along the creek. Thus, the zone has a probable length of over 200 feet (60 m) and a width of about 50 feet (15 m), the latter according to Weiss. The rock southeast of the creek, as for example in the quarries east of the adit entrance, is granite pegmatite and gneiss. Similarly, the large quarry shown on the topographic map about 575 feet (175 m) west of the adit is in granite pegmatite (Geyer et al., 1976).

Although the 1:24,000 aeromagnetic map (Bromery and others, 1960) shows no anomaly in this area, the Coatesville pyrrhotite body should be traceable by geophysical means, as for example, by electromagnetic or ground magnetometer surveys. Contrasting U, Th, and K contents in this area should also permit the tracing of geologic contacts by gamma-ray spectrometry. Geochemical analyses of B-zone soil samples should also delineate mineralization. Sufficient sulfides are present to produce "yellow boy" (various ferric hydroxides) in the creek. Beryl, in potentially economic amounts, also occurs in the area in pegmatites (Smith, 1972a).

As correctly noted by Weiss, the Coatesville pyrrhotite body has affinities[6] with the Ducktown-type massive sulfide deposits of Tennessee (Magee, 1968) and Gossan Lead, Virginia. As such, the mineralization may reflect structural control of a metasedimentary host rather than being a contact phenomena. By analogy to Ducktown and Gossan Lead, the metal values could be zoned both regionally and locally from magnetite to pyrrhotite to pyrite to chalcopyrite with sphalerite. Such deposits could also be related to local jogs in regional metamorphic isograds (Stuart Maher, personal commun., 1972). One of the possible pyrrhotite-forming reactions[7] suggest that carbonate minerals (like the observed ferroan dolomite) could be useful exploration guides to buried mineralization. The country rock surrounding the sulfides could be enriched in carbonates. Soil geochemistry for copper and perhaps zinc and nickel should work well in defining the limits of occurrence.

5. Subject to error because of the large quantities of pyrrhotite and trace magnetite.
6. Some of the affinities include pyrrhotite, pyrite, chalcopyrite, magnetite, and graphite in Precambrian metasedimentary schistose rock.
7. $2H_2O + C + 2FeS_2 \rightarrow 2FeS + 2H_2S + CO_2$
$\text{"FeO"} + H_2S \rightarrow FeS + H_2O$

CAMBRIAN OCCURRENCES

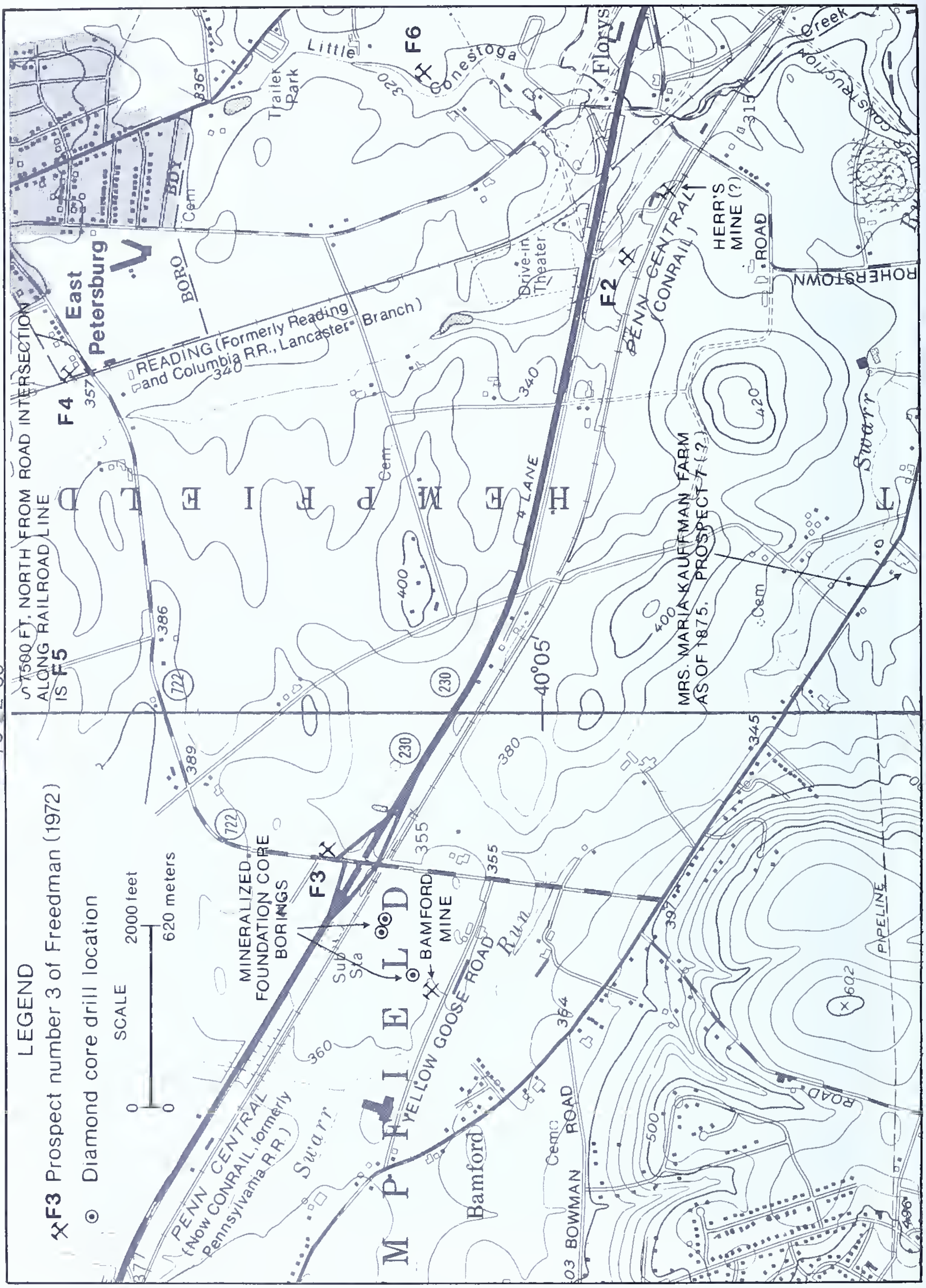
3. BAMFORD MINE AREA, LANCASTER COUNTY

(Former Zinc Producer)

1. *Name:* The Bamford mine was formerly owned by J. Irvin Denlinger, but is reported to have been sold in the early 1970's to the Kellogg Company of Battle Creek, Michigan. Samuel Pickel, a fence maker, discovered the occurrence while digging postholes during the Mexican War. The name Bamford came from the Bamford Brothers pork packers of Cheshire, England, who invested heavily in the mill and mine (see Figure 2). The nearby Herr's mine, as located in this description, is on the Pennsylvania Central Railroad (ConRail) right-of-way. Prospect 3 is reported to be owned by David L. Landis. The history of mining in the Bamford area is described by Loose (1972) and well summarized by Freedman (1972).

2. *Location:* A. The prospect locations of Freedman (1972) and the author's best estimate of the locations are presented in Figure 3. The wooded area which includes the Bamford mine workings is located 0.3 mile (0.5 km) southwest of the intersection of Pennsylvania Routes 230 and 722, 0.25

Figure 2. Bamford zinc works shortly after 1900. (From a postcard by D. B. Landis, courtesy of J. W. W. Loose, Lancaster County Historical Society.)


LEGEND
F3 Prospect number 3 of Freedman (1972)
Diamond core drill location
SCALE
0 2000 feet
0 620 meters
MINERALIZED FOUNDATION CORE BORINGS
BAMFORD MINE
F2
F3
F4
F6
1500 FT. NORTH FROM ROAD INTERSECTION ALONG RAILROAD LINE IS F5
East Petersburg
BORO
READING (Formerly Reading and Columbia RR., Lancaster Branch)
PENN CENTRAL (CONRAIL)
HERR'S MINE (?)
MRS. MARIA KAUFFMAN FARM PROSPECT 7 (?) AS OF 1875.
PENN CENTRAL (Now CONRAIL, formerly Pennsylvania R.R.)
YELLOW GOOSE ROAD
BOWMAN ROAD
ROHERSTOWN ROAD
Little Conestoga Creek
Swarr Run
Drive-in Theater
Trailer Park
PIPELINE
Florys
Bamford
HEMPFIELD
4 LANE
76°22'30"
40°05'

mile (0.45 km) northeast of the town of Bamford, and 0.3 mile (0.5 km) west-northwest of the intersection of Yellow Goose Road and Pa. Route 722. The reported mines themselves are located on the north side of Yellow Goose Road 1900 feet (580 m) west-northwest of its intersection with Pa. Route 722 and 75 feet (23 m) north of Yellow Goose Road. (See Figure 4 from Freedman, 1972, for a detailed map of the Bamford mine area.) The Bamford mine is Prospect 1 of Freedman (1972). One shaft, cleaned out in 1975 (see Figure 5), is located 83 feet (26 m) north of Yellow Goose Road and 169 feet (52 m) west of the end of the Denlinger chicken house (farm building of Figure 4 of Freedman, 1972; Jerri L. Jones, personal commun., 1974). A. V. Heyl (personal commun., 1976) reports possible additional exploration diggings across Yellow Goose Road to the southwest of the mine on the apparent mineralization trend. Crops prevented the present author from examining the area south of Yellow Goose Road.

In contrast to Freedman's location (1972, Plate I, Prospect 2), the author believes that Herr's mine may be located along the south side of the Pennsylvania Central Railroad (ConRail) line west of Roherstown Road. Three pits or underground openings, which became apparent after the extremely heavy rains associated with Tropical Storm Agnes in 1972, are observable 244 feet (74.3 m), 302 feet (92.0 m), and 414 feet (126.0 m) N47W along the south side of the tracks from the center of Roherstown Road. The main opening is 10 feet (3 m) south-southwest of the southernmost of the four steel rails (Figure 6). This location is 390 meters (1275 feet) west of the crossing of the Little Conestoga Creek by the railroad and compares favorably with the "about 400 meters" (about 1300 feet) reported by Frazer (1880), versus about 730 meters (2400 feet) for Freedman's location.

As located in this report, Herr's mine area is 0.25 mile (0.35 km) southwest of the Pa. Route 230 bridge over Little Conestoga Creek. Frazer (1880, p. 56) reports that Herr's mine was S75E of the Bamford mine, which fits both possible locations.[1]

Sphalerite was found by the author at Prospect 3 of Freedman (1972, Plate I) located about 400 feet (120 m) north-northeast of the overpass of Pa. Route 722 over Pa. Route 230, 1.9 miles (3 km) due south of Mechanicsville, and 0.4 mile (0.65 km) northeast of the Bamford mine. This locality is probably the north end of an area of prospects described by Frazer (1880, p. 201) as follows: "These veins have been traced on the property for a distance of *about half a mile* and ore has been found in an excavation made on the side of the Petersburg Township road, just beyond the *Pennsylvania railroad*." (All italics by the present author.) David L. Landis reported the filling of this prospect pit here only a few years ago (J. L. Jones, personal commun., 1974). Freedman (1972, p. 34), however, equates this

1. A. V. Heyl (personal commun., 1976) reports a good photo of Herr's mine in Eyerman (1911). Eyerman (1911) was a limited edition with different copies having different photographs; however, copies examined by the author contain photographs of the Ueberroth mine, etc.

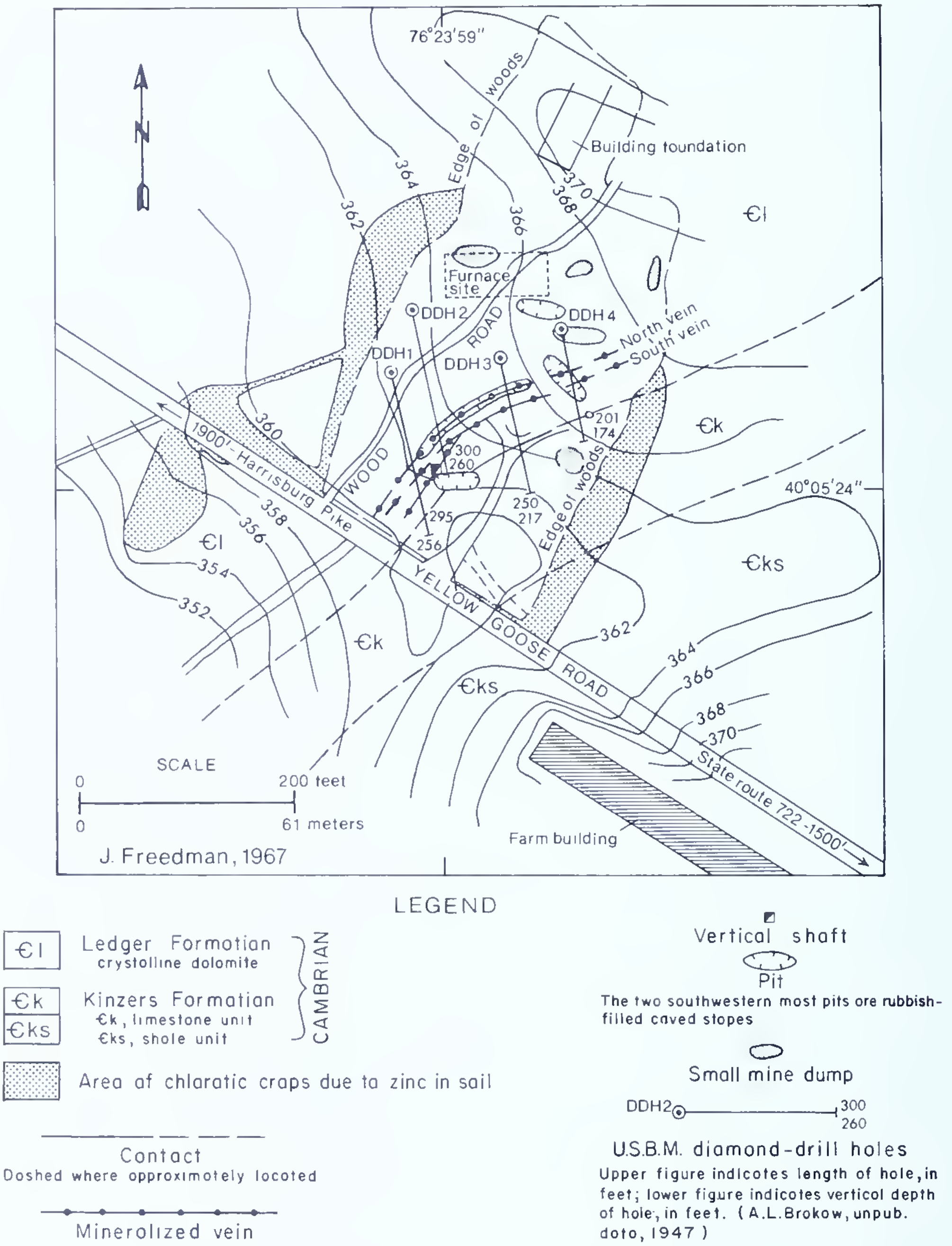


Figure 4. Bamford zinc mine, Lancaster Co. (Freedman, 1972, p. 16).

quotation with his Prospect 4 which his map (Plate I) locates along the *Reading Railroad 1.5 miles (2.4 km)* northeast of the Bamford mine. Freedman's text (p. 34) refers to his Prospect 4 as being along the *Penn Central Railroad* (instead of the Reading Railroad) about 1/4 mile southwest of East Petersburg and refers to Prospect 3 in another paragraph.

Plate I of Freedman (1972) locates Prospect 4 north of the intersection of Pa. Route 722 and a single track of the Reading Railroad referred to as the

Figure 5. Open trench of Bamford mine as it appeared during construction in 1975. (Photo courtesy of Jeri L. Jones, York.)

Penn Central Railroad in his text (p. 34) as noted above. Frazer (1880, p. 201) described this occurrence as follows: *"About a mile and a half further north-east,* another deposit of calamine was cut through in building the Lancaster Branch of the Reading and Columbia railroad. At that point considerable ore was taken out. . ." Although Frazer's location is precise, the owner of the Prospect 4 area knew nothing of a prospect and nothing was observed in the rocks or soils which would tend to confirm the exact location.

Plate I of Freedman (1972) locates his Prospect 5 along the Reading Railroad about $1^1/_2$ miles *northwest* of Prospect 4, whereas the text of Freedman (p. 34) notes that it is about $1^1/_2$ miles *northeast* of Prospect 4. It appears that Freedman's basis for locating a prospect here is Frazer's (1880, p. 201), "About a mile and a half further north-east. . ." which the present author interprets as referring to Prospect 4. The present author thus concludes that: a) Freedman may have misinterpreted Frazer (1880, p. 201) and confused the descriptions of Prospects 5, 4, and 3, and b) that there is no apparent evidence in Frazer for Prospect 5. Prospect 5 of Freedman is in an unscarred corn field. Roughly 800 feet (about 240 m, but paced under difficult conditions) to the north there is a substantial pile of brecciated carbonate rock probably collected from along the thrust of Buffalo Springs Formation over Stonehenge Formation (Meisler and Becher, 1971). Vein dolomite, but neither sphalerite nor smithsonite, was observed in 25 boulders broken into small chips. The owner states that this scar is an active sinkhole. Prospect 5 will not be discussed further.

Prospect 6 of Freedman (1972, Plate I) was not examined by the present author. Freedman found no minerals or strong geochemical data which would indicate zinc or lead.

Figure 6. Probable entrance to Herr's mine along ConRail (Penn Central) tracks after cave-in in June, 1972.

Prospect 7 of the present discussion was reported by Landis (1904, p. 244-245) to have been leased by the Lehigh Zinc and Iron Company, of Bethlehem, Pa. Landis calls this the Widow Kauffman property. If this is the same as the Mrs. Maria Kauffman property as recorded in 1875, it is located on the corner of Long Lane and Harrisburg Pike, 1.35 mile (2.2 km) southeast of the Bamford mine.

Genth (1855) also implies zinc mineralization at ". . . the Hoffman lot, of about eight acres, on the northeast side of the railroad."

All of the occurrences listed above are in East Hempfield Township, Lancaster County.

B.	LATITUDE N	LONGITUDE W
Bamford mine (Prospect 1 of Freedman, 1972)	40° 05′ 13″	76° 23′ 11″
Herr's mine (Prospect 2 of Freedman, 1972)	40° 04′ 44″	76° 21′ 15″
Prospect 3 of Freedman (1972)	40° 05′ 24″	76° 22′ 48″
Prospect 4 of Freedman (1972)	?	?
Mrs. Maria Kauffman farm building (Prospect 7)	40° 04′ 20″	76° 22′ 09″

C. TOPOGRAPHIC MAP: The Bamford mine and Prospect 3 are on the Columbia East $7\frac{1}{2}$-minute quadrangle, whereas Herr's mine and Widow Kauffman's are on the Lancaster $7\frac{1}{2}$-minute quadrangle.

3. *Host Rock:* According to the geologic map of Meisler and Becher (1971), the host rock at the Bamford mine is the lower part of the Ledger Formation, "a light-gray, coarsely crystalline dolomite" near the underlying upper part of the Kinzers Formation, "a limestone commonly containing reticulated silty and argillaceous laminae; some dark-gray earthy dolomite." The more detailed map of Freedman (1972, Figure 3; and Figure 3 of this report) also shows the veins as being in lower Ledger Formation.

Herr's mine is located in a limestone, mapped as Kinzers Formation by Meisler and Becher (1971), which has a resistant network of silty laminae. Prospect 3 is in coarsely crystalline dolomite of the Ledger Formation. No mineralization was observed at Prospect 4, but the area has been mapped as Zooks Corner Formation, a finely crystalline dolomite. The area suspected as Widow Kauffman's prospect has been mapped as crystalline dolomite of the Cambrian Vintage Formation (Meisler and Becher, 1971). Thus, at least four Cambrian-age carbonate formations may be mineralized.

4. *Estimated Amounts of Ore Metals:*

A.	Bamford mine	Herr's mine[2]	Prospect 3[3]	Prospect 4	Widow Kauffman's Prospect 7
<1 g:					
1-1000 g:	Sb				
1-1000 kg:	Cu, As				
>1000 kg:	Zn, Pb, Ag	Zn	Zn?	Zn?	Zn?

Mosier (1948) estimated the removal of 25,000 tons of ore and waste rock from the Bamford mine, and Freedman (1972) estimated 67,000 tons of ore. In Frazer (1880, p. 201) E. G. Spilsbury reports the average sphalerite content of the ore was ". . . about 17 to 18 per cent. . ." (11.4 to 12.1% Zn) for a year's workings and that for the south vein, ". . . the average amount of zinc in the vein never exceeded 12 per cent. . ." Assuming that the ore averaged about 12 per cent Zn and that about 10,000 tons of ore itself was mined, a production of 1,200 tons or about 1,200,000 kg of Zn results. At February 1974 prices, this would have a value of $770,000 for zinc, and if the ore contained 1% Pb, a value of about $38,000 for lead. Genth (1855) reported 180 tons of ore in stockpiles.

Herr's mine produced at least 80 tons of calamine and sphalerite (Frazer, 1880, p. 56), and Widow Kauffman's prospect only ". . . some small lots of zinc ore" (Landis, 1904, p. 245). Prospect 4 of Freedman probably produced several tons of zinc ore.

B. ASSAYS: E. G. Spilsbury (Frazer, 1880, p. 200) reported the average of 14 sphalerite analyses as containing 0.81% Fe and 0.07% Cd. Freedman (1972) reports an analysis of separated sphalerite by the U. S. Geological Survey as containing 420 ppm or 12.3 oz. of Ag per ton of sphalerite. If this sample is representative of past production, about $100,000 in silver was unrecovered from sphalerite at Bamford. Freedman reported detecting argentite (acanthite) by X-ray diffraction in this and another sample. By emission spectroscopy, Lenker (1962) found that pure sphalerite from Bamford contained 0.390% Fe, 0.146% Cu, 0.126% Cd, 16 ppm Ge, 85 ppm Ga, and 10 ppm Mn. Lenker did not detect Bi, Mo, Sn, Co, and In. Also by emission spectroscopy, A. V. Heyl (personal commun., 1968) found that pure, picked sphalerite from Bamford contained 1% Fe, 0.5% Cd, 50 ppm Mn, 7 ppm Ag, 3 ppm Bi, 150 ppm Cu, and 7 ppm V by semiquantitative emission spectrographic procedures. Heyl did not detect As or Sb, but the detection limit for As was probably 200-400 ppm.

E. G. Spilsbury (Frazer 1880, p. 200) reported that galena ". . . taken from one bench or pocket, will run up to $2,000 of silver per ton, whereas adjoining pieces would perhaps contain a couple of dollars to the ton." This he attributed to inhomogeneous distribution of minute grains of tetrahedrite. Spilsbury reported an average value of $22 in Ag per ton of galena, presumably at a price of about $1 per ounce of silver. At February 1974 prices, this would be about $100 to $125 in Ag per ton of galena. If the past production of about 100 tons of galena is correct, the silver value of the galena would be about $100,000. Freedman (1972) reports that one hand

2. Frazer (1877, p. 56) reports a production of about 80 tons of "calamine(?)" and sphalerite ore. Eyerman (1911) suggests it was reopened in the 1900's. Otherwise, production records for the ores are incomplete.
3. The question marks suggest that zinc may not be present at the exact locations shown in Figure 3. Zinc is known to have been present at the actual occurrences. In the case of Prospect 4 near East Petersburg, Frazer reported "considerable ore taken out."

specimen of galena contained 150 ppm Ag or 4.4 oz. Ag per ton of galena (about $25 per ton of galena concentrate). A. V. Heyl (personal commun., 1968) reported that Bamford galena with possible tetrahedrite inclusions, analyzed by fire assay-atomic absorption, contained 200 ppm Ag, 0.05 ppm Au, and 0.07 ppm Hg. Genth (1855) reported 1 oz. Ag/ton of pure galena from a 1- to 3-inch- (3-8 cm) wide vein. It is concluded that sphalerite and galena from Bamford are inhomogeneous and that some samples may contain finely disseminated sulfosalts. The total zinc, silver, and lead production from Bamford is thus estimated to have been on the order of one million dollars.

5. *Minerals Observed and Relative Amounts:*

A. ECONOMIC

Bamford mine	Herr's mine	Prospect 3	Prospect 4
Major: Sphalerite (lemon-yellow core and black rim)	Smithsonite(?),[4] sphalerite[4]		Smithsonite and/or hemimorphite[4]
Minor: Smithsonite, galena		Sphalerite (lemon-yellow core and black rim)	
Trace: Chalcopyrite, cerussite, anglesite, greenockite, aurichalcite,[5] argentite (acanthite),[5] hydrozincite,* tennantite$_{0.8}$-tetrahedrite$_{0.2}$, hemimorphite[6]		Smithsonite	

B. GANGUE

Bamford mine	Herr's mine	Prospect 3	Prospect 4
Major: Dolomite (white crystalline and gray rock)		Dolomite	

* Asterick refers to all samples verified by X-ray powder diffraction analyses.

Minor: Pyrite, muscovite var. sericite, specular hematite[4]	
Trace: Quartz	Pyrite, calcite

6. *Paragenesis:* Highly uncertain, but the following sequence seems possible from hand specimen examination: dolomite host rock; possible solution brecciation;[7] light sphalerite; dark sphalerite,[8] pyrite, white crystalline dolomite, galena (some on dolomite crystals in cavities) and chalcopyrite. Spilsbury (in Frazer, 1880) reported that the galena was found chiefly in bunches or little strings running along or near the hanging wall, whereas the sphalerite was disseminated throughout the ore body.

7. *Geologic Description:* The Bamford mine is located on the north limb of the Chickies-Chestnut Hill anticline about 2 miles (3 km) northwest of its eastern terminus (Jonas and Stose, 1930). The eroded core of the anticline exposes Cambrian Chickies, Harpers, and Antietam Formations and Precambrian rocks may be present only a few hundred feet below the surface. In York County, Precambrian metabasalts such as those at Accomac have been thrust out of the core of the Chickies anticline which is the western end of the same anticline as Bamford (Stose and Jonas, 1939). Meisler and Becher (1971, p. 33-34) refer to the portion of the Chickies-Chestnut Hill anticline in which the Bamford mine is located as the North Chestnut Hill anticline and note that this is not a simple fold, but rather a series of smaller folds. They also suggest several stages of deformation by noting the sharp curvature of the Chickies thrust which terminates the North Chestnut Hill anticline on its west side. Meisler and Becher (1971, p. 30) generalize the structure as follows:

> The most prominent structure present is the complex anticlinal uplift whose crest occurs generally in the quartzite ridges. Folds in this zone are generally open and upright, although some tighter folds, slightly overturned to the north are present. . . . Faulting,

4. Reported by Frazer (1880) but not observed during the present study.
5. Reported by Freedman (1972) but not observed during the present study.
6. Reported by A. V. Heyl (personal commun., 1976).
7. With polished sections, Freedman (1972, p. 26) was able to detect a post-sphalerite tectonic brecciation as well as the possible solution brecciation noted here.
8. During the present study, lemon-yellow sphalerite was commonly observed to be rimmed by a dark, almost black variety. Freedman (1972, p. 24) reported "Two varieties of sphalerite were observed: an early dark-brown to black variety and the later pale-golden-yellow transparent to translucent variety which makes up most of the sphalerite content." Freedman's age relations are normal for most districts; and his relations are based on polished sections. However, the sphalerite in vuggy, coarse, white vein dolomite observed by the author is also dark. This does not rule out the possibility of trace amounts of late, light-colored sphalerite.

> including thrust faulting, has added to the structural complexity of this zone.

From the Bamford mine geologic map of Freedman (1972, Figure 4) and from the 72N dip of the ore of Spilsbury (in Frazer, 1880), it appears that the Bamford mine mineralization is in the lower Ledger Formation (Figure 4). The immediate ore control could be a solution breccia as suggested by Freedman or a tectonic breccia resulting from the folding of a competent dolomite (Vintage Formation) about an incompetent limestone (Kinzers Formation) as suggested by the present author. The occurrence of significant mineralization in the Kinzers Formation (Herr's mine), Zooks Corner Formation (Prospect 4), and possibly the Buffalo Springs Formation of the Conococheague Group (Prospect 5?), suggests that host rock and/or solution breccias (usually limited to selected horizons amenable to solution) are not large-scale controls.

The local control provided by bedding is emphasized by Spilsbury (in Frazer, 1880, p. 198-199):

> The veins at the Bamford mine are most unmistakably "bedded veins", and not fissures or gash veins. They are conformable both to the stratification and dip of the enclosing rocks, their general course being about 74° 35′ east of North, and dipping at an angle of 18° from the vertical . . . . The roofs or hanging walls are, in each case, well defined and regular, although the Limestone of the hanging wall has a decidedly brecciated appearance, is partially decomposed, of a whitish grey color and highly siliceous. It is full of seams and cavities, some of the latter attaining the dimensions of small caves being from 15 to 20 feet long and equally broad, with a height of from 4 to 6 feet. All these seams and openings are completely filled in with a dark red sandy loam, differing in that respect from the Limestone caves of the Lead and Zinc regions of Missouri and Illinois, which are invariably filled with mineral. In none of the cavities examined in this mine have I ever found a trace of mineral.

To the present author this suggests that the clay-filled cavities are the result of solution during the Recent. The lowest Paleozoic unconformity found by Jonas and Stose (1930) was at the top of the Cocalico Formation, a shale, about 7000 feet (2200 m) stratigraphically above the Kinzers Formation. In places, the Conestoga Formation is deposited on the Vintage Formation (Jonas and Stose, 1930, Plate X and p. 45), so that if their interpretation of the Conestoga Formation is correct, solution breccia is possible over a great stratigraphic interval. Because of structural complexity, undiscovered unconformities may exist. A more likely interpretation of the Conestoga Formation is noted in the Pequea report, and it is possible that the ore solutions may form their own solution-collapse breccia host.

As noted above, the general strike of the veins in the Bamford mine was N74E and the dip 72N. Spilsbury (in Frazer 1880, p. 201) described the veins and workings as follows:

> At the Bamford mine, both the veins have been opened upon and worked down to the 75-foot level, and the south vein has been cut at the 110-foot level.
>
> The north vein has been opened on a length of over 300 feet, had an average width of 12 feet, and has been worked out to a depth of 50 feet, and cut and explored on the 75 foot level. Below the 50-foot level, however, it was found everywhere to be perfectly barren.
>
> The south vein, which was the most regular and the most profitable, has now been worked out to the 75-foot level, and on a length of over 400 feet. The average width is from 14 to 18 feet. Although in some portions the ore was very rich, still the average amount of zinc in the vein never exceeded 12 per cent, and no ore was ever pure enough to treat without a previous concentration, excepting, of course, the surface deposits of calamine. The richest ore occurred at about fifty feet from the surface, and from there down to seventy-five feet. At the 110-foot level, although the vein is well defined, there is little or no ore in it, at any of the points where it has been opened, and what little ore is in it, appears in strings, and not disseminated, as above.

As described by Frazer (1880, p. 55) the excavation at shaft No. 1 trended N75E and the vein strike was about N70E with a dip of 15N at the surface and *15S about 15 feet* (5 m) beneath the surface. A winze shaft sunk at the west end of this excavation cut two or three zinc-rich zones. At shaft No. 2, the vein was reported to trend N85E. Genth (1855) described the south vein as 12 feet (3.7 m) thick and dipping 32° to the north.

The two veins were reported to be on the order of 50 feet (15 m) apart on the surface. Of 28 shallow core borings taken for foundation studies in 1974 and logged by the author, only four contained zinc mineralization. The first of these was in the mine area, the second 275 feet (85 m) N30E, the third 900 feet (280 m) N57E, and the fourth 950 feet (290 m) N61E of the old mine site. None of these was a good ore intercept.

When visited in August 1972, after the flooding associated with tropical storm Agnes, the main opening at Herr's mine was 7 feet (2.2 m) wide and an average of 2 feet (0.6 m) high, but much railroad ballast had already washed in, raising the floor (see Figure 6). The floor of the mine dipped south at about 30° to 40° (not measured). At approximately this location, Meisler and Becher (1971) determined that the attitude of bedding was E-W, 5N. About 400 feet (120 m) to the southeast, they found that the strike was similar, but that the dip was 70S. It seems possible that the ore at Herr's mine was in the crest of a small fold. Frazer (1880, p. 56) reports that the limestone trended N10E, 50E. There were two, small sinkhole-like collapse areas 58 feet (28 m) and 112 feet (34 m) to the east and west of the main opening, respectively. These are also 10 ± 1 feet (3 ± 0.3 m) south-southwest of the southernmost of the four iron rails. One B-zone soil sample collected by the author 8-12 inches (20-30 cm) beneath the surface, but directly above

the main opening of Herr's mine, was found to contain 210 ppm Zn, 80 ppm Pb, 30 ppm Cu, and <0.1 ppm Ag. Herr's mine is just east of the area covered by Freedman's soil sampling, but very near to the edge where he obtained 100-300 ppm Zn and 50-100 ppm Pb. The relative agreement is good and the author's absolute values suggest weak anomalies for zinc and lead.

As noted, the Widow Kauffman prospect is reported to have yielded only a few small lots of zinc ore.[9] Freedman (1972) shows a lead soil anomaly in the 150 to 1000 ppm range on the Mrs. Maria Kauffman farm of 1875, so this may be the area of the Widow Kauffman prospect (i.e., the area near the intersection of Long Lane and Harrisburg Pike.

Landis (1904, p. 246) reports ". . . frequent evidences of zinc, lead and traces of silver along the meadows of Snapper Creek, cropping out, as they do, in various farms toward the south of East Petersburg." Unfortunately, Snapper Creek is not identified on the various Lancaster quadrangle or old township maps, but there are only a few possibilities. In November, 1900, the Longenback and Morton zinc smelters of Canton, Ohio, leased the D. Grube, F. Kreider, P. Swarr, and other farms over a distance of 1.75 miles (2.8 km) between Bamfordville and Shreiner's station (Landis, 1904), but the results are not available.

Interpretation of Freedman's soil geochemical sampling program is difficult because of the difference in sampling techniques within the survey. Grauch (1966), who did the sampling for the Bamford area under Freedman's direction described their procedure.

> This grid was not strictly adhered to, as an area 100 feet or so from the designated station may have held greater promise of a concentration of metal. For instance, a topographic low would be more likely to contain higher percentages of metal than the percentages found on a slope. . . . The depth from which the sample was taken was determined by the depth to which the soil corer could be pushed by hand. . . . Whenever possible, rock specimens were collected instead of soil samples. The reason for this seems to be fairly obvious. The rock will give a higher and more precise value than its overlying soil.

Because the distribution of many of the zinc geochemical anomalies reported by Freedman appears to be independent of host rock and known structure, some of the reported zinc anomalies may be related in part, to metal accumulation in low-lying, humus-rich areas: 0.5 mile (0.8 km) northeast of the Bamford mine, 1.0 mile (1.6 km) north, 1.25 miles (2 km) northwest, and 0.5 mile (0.8 km) west of the Bamford mine. Two interesting zinc anomalies reported by Freedman are located 1.45 miles (2.3 km) west-southwest and 1.15 miles (1.85 km) southwest of the Bamford mine. These two occur on a northeast-dipping thrust of lower Cambrian clastic rocks over Ordovician Zooks Corner Formation (Meisler and Becher, 1971). The most

9. This could be interpreted as several hundred pounds of 20-30% ore.

interesting lead plus zinc anomaly is located 0.8 mile (1.25 km) southeast of the Bamford mine on the Antietam-Vintage contact which is known to contain sphalerite and galena along the Susquehanna River to the southwest.

Helen L. Cannon (personal commun., 1973) reported the results of some geochemical water analyses done in 1947 in which she found the following:

Location	Heavy Metal in Water
Quarry 500 feet west of Bamford mine	0.50 ppm
Swarr Run just west of quarry above	.33 ppm
Swarr Run ½ mile southeast of Bamford mine	.15
Little Conestoga Creek ¾ mile south of Swarr Run	.15
Little Conestoga Creek near Millerstown	.06

Cannon correctly emphasized:

> It should be noted that there is no drop in the ppm from the sampling station on Swarr Run just below the mine to the sampling station on the Little Conestoga just below the confluence as should be expected. This would indicate that there is sufficient mineralization along the main stream to the north to account for this high content. A small amount of mineralization was found along a railroad cut west of East Petersburg, but nothing large enough to cause this anomaly.

The geochemical anomaly on the Antietam-Vintage contact and the Widow Kauffman prospect may account for the long dispersion train, as could in part the old smelter and prevailing westerly winds.

As noted by Cannon, "A large patch of chlorotic[10] soy beans, stunted to a height of 3-4 inches was observed west of the workings, probably affected by smelter contamination." Freedman's (1972) Figure 6 and Figure 7 of this report show stunted corn growing in the same area. When visited by the author in 1967, it was possible to walk out a southwest trail of fresh sphalerite float by following the chlorotic corn. No smithsonite was observed on this trail, and the samples had only a thin weathering rind. This suggests the zinc source is old dumps, rather than natural veins or smelter contamination. It is still very likely, however, that smelter contamination has drastically effected the distribution of zinc in soils of the Bamford mine area. For a few years, there were 244 retorts and condensers distilling zinc.

The geochemical stream sediment sampling of Rose (1971, p. 29) suggests that further study is warranted in his drainage cell numbers 253 and 243.

Freedman (1972) and A. V. Heyl (in Freedman, 1972) have questioned whether some of the limonites in the Grubb Lake area, about 4 miles (6.4

10. Yellowed and blanched, probably due to malfunction of chlorophyll with zinc replacing magnesium.

Figure 7. Stunted corn in the zinc-rich soil southwest of the Bamford mine. The fresh nature of zinc minerals in the soil suggests mine waste, rather than a natural soil anomaly.

km) southwest of the Bamford mine, were actually gossans over sulfide deposits. Their point is valid whether the limonite occurred on the Antietam-Vintage normal contact (Jonas and Stose, 1930) or on Antietam-Ledger thrust contact (Meisler and Becher, 1971). Both contacts could be loci of zinc-lead mineralization. Charles Lesley (1856) described galena in limonite from near Marietta, Pa. However, analyses (reported in ppm) of limonites from these areas contain "normal" amounts of base metals compared to numerous limonites from elsewhere in Pennsylvania:

Name	Latitude N Longitude W	Formation	Co	Ni	Cu	Zn	As	Ag	Pb
Duffy, Marietta *	40°03′53″ 76°32′51″	Є Vintage	80	125	25	945	65	<.1	60
Mud Lake **	40°03′22″ 76°27′09″	Є Vintage	290	335	80	1300	10	<.1	50
Grubb Lake ***	40°03′36″ 76°26′51″	Є Vintage(?)	195	215	135	910	10	<.1	40

*58 one-inch chips **88 one-inch chips ***50 one-inch chips

4. BILLMEYER QUARRY, LANCASTER COUNTY

(Minor Lead-Copper-Arsenic-Silver Occurrence)

1. *Name:* The Billmeyer quarry is owned by the J. E. Baker Company, and the plant by W. S. Frey Company.

2. *Location:* A. Three mineralized areas occur on the southwest side of a large dolomite quarry at the former village of Billmeyer (Figure 8). These areas are 0.2 mile (0.35 km) north of the Susquehanna River and 1.7 miles southeast of Bainbridge, Conoy Township, Lancaster County.

Occurrence No. 1 is approximately 225 feet (70 m) west-northwest of the northwest edge of the diabase dike (which forms Haldeman Riffles in the river). Occurrence No. 2 is approximately 500 feet (150 m) west-northwest of the same dike. Occurrence No. 1 is approximately 110 feet (34 m) S35E of the south end (corner) of the quarry and occurrence No. 2 is approximately 265 feet (80 m) N68W of occurrence No. 1. Occurrence No. 3, not observed during the present study, is reported by L. J. Duersmith (personal commun., 1972) to have been located in the southwest quarry face as of 1963, approximately 1350 feet (415 m) northwest of the diabase dike. The galena occurred about 10 feet (3 m) below the quarry rim and the tetrahedrite about 135 feet (41 m) farther northwest about 60 feet (18 m) below the rim.

	Occurrence No. 1	Occurrence No. 2	Occurrence No. 3
B. LATITUDE N:	40° 04′21″	40° 04′22″	40° 04′27″
LONGITUDE W:	76° 38′49″	76° 38′53″	76° 39′05″

C. TOPOGRAPHIC MAP: York Haven $7\frac{1}{2}$-minute quadrangle.

3. *Host Rock:* Ledger crystalline dolomite of the Cambrian period, but close to the contact with the underlying Cambrian Vintage dolomite.

4. *Estimated Amounts of Ore Metals:*

A. <1 g:

1-1000 g: Ag, Sb, Bi, Zn

1-1000 kg: As, Cu, Pb

>1000 kg:

B. ASSAYS: A. V. Heyl (personal commun., 1968) reports a semi-quantitative analysis of a piece of pure galena as: Ag 0.1%, Bi 0.07%, Cu 0.3%, and Sb 0.3%.

5. *Minerals Observed and Relative Amounts:*

A. ECONOMIC

	Occurrence No. 1	Occurrence No. 2	Occurrence No. 3
Major:	Tetrahedrite-tennantite		Galena, tetrahedrite

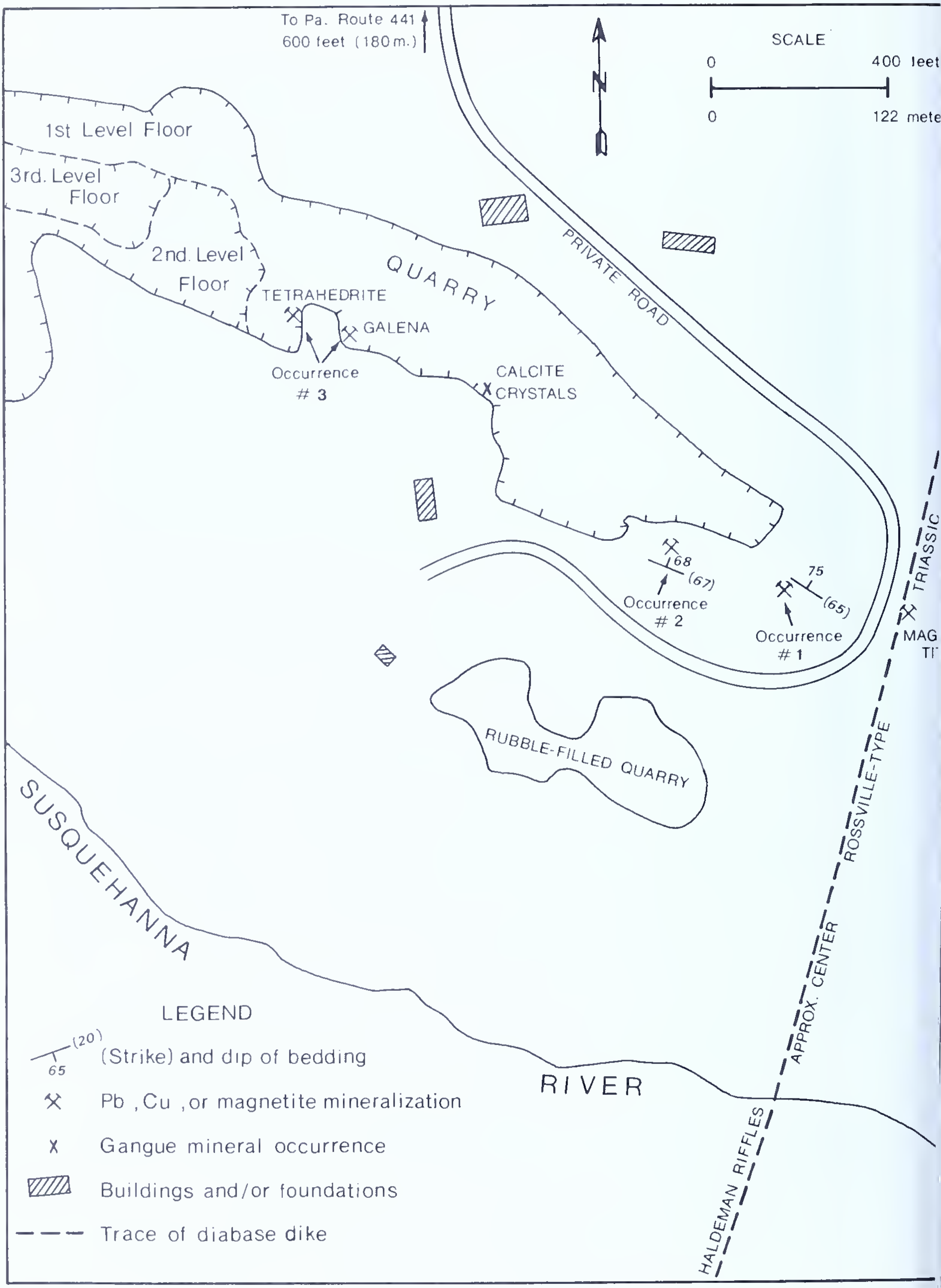


Figure 8. Metallic occurrences at the J. E. Baker quarry, Billmeyer, Lancaster Co. Location of magnetite and #3 occurrence courtesy of L. J. Duersmith.

Minor:	Chalcopyrite	Tetrahedrite-tennantite, tetrahedrite var. freibergite or fredricite,[1] malachite	Malachite (fibrous and microcrystals)
Trace:	Galena, bornite, azurite (thin films), sphalerite (black)	Acanthite, azurite (thin films)	Native silver, sphalerite (golden), azurite (microcrystals) cerussite (personal commun. Paul Seel to L. J. Duersmith 5/26/75) chalcopyrite (some disseminated in tetrahedrite), smithsonite, anglesite, covellite,[2] digenite(?)[2]
B. GANGUE			
Major:		Quartz	Quartz
Minor:	Dolomite (white)	Dolomite (tan)	Jarosite* (red-brown)
Trace:			Dolomite (inclusions in quartz crystals)

Gypsum and fluorite occurred in trace amounts and calcite in large scalenohedrons elsewhere in the quarry (L. J. Duersmith, personal commun., 1974).

6. *Paragenesis:* The tetrahedrite and galena at occurrence No. 2 are in the margins of the quartz veins. In polished sections: galena, chalcopyrite, digenite(?), covellite, and tetrahedrite.

7. *Geologic Description:* The Billmeyer quarry is located in the north limb of a west-northwest trending anticline, the southern limb of which is extensively faulted.

Occurrence No. 1 consists of a few, approximately ¼-inch- (0.5 cm) wide dolomite veinlets which contain sparse, discontinuous blebs up to about 1 inch (3 cm) of tetrahedrite-tennantite (estimated to comprise 80%

1. Qualitative X-ray fluorescence scans suggest major Cu, Fe, Zn, minor As, trace Ag, and no Sb.
2. Observed only in polished sections.

* Asterick refers to all samples verified by X-ray powder diffraction analyses.

of the metallic minerals), chalcopyrite plus bornite (15%), and galena (5%). These veinlets trend N32E, 81W. The host rock is a light-gray crystalline dolomite with an indeterminate attitude here, but approximately 45 feet (14 m) to the northeast there is a 20 ± 2-inch- (50 ± 5 cm) thick oolitic bed which trends N65W, 75N and there are no obvious structures between this oolitic bed and the mineralization. In the area between the oolitic bed and the mineralization, there are two pronounced sets of joints with $^1/_2$- to 2-inch (1-5 cm) spacings. One joint set trends N18E, 75W and the second trends N65E, 26W, but there is a range of attitudes within both joint sets.

Occurrence No. 1 is located approximately 225 feet (70 m) west-northwest of a Rossville-type, Triassic diabase dike with bytownite-anorthite phenocrysts in its fine-grained borders. The chilled contact of this dike contains 0.80% TiO_2; 175 ppm Cr, 54 ppm Co, 61 ppm Ni, 69 ppm Cu, and 79 ppm Zn in its chilled selvage, is unaltered, and is very similar in composition to other Triassic dikes of the Rossville type (Smith, 1973).

Occurrence No. 2 consists of four separate mineralized quartz veins which are $^3/_4$ inch (2 cm), 1 inch (3 cm), $1^1/_4$ inches (3 cm), and 2 inches (5 cm) wide. The tennantite blebs are $^1/_2$ to 1 inch (1-3 cm) in the longest dimension and the galena blebs up to $^1/_2$ inch (1 cm), but neither variety of bleb was observed to occur closer than a few inches from either a similar or different metallic mineral bleb, i.e., the veins are lean with an estimated ore-mineral content in the veins of 2% or less. The mineralized quartz veins trend N18E, 73E to 80W. These veins are mineralized only where they cross certain beds. Bedding in the area of occurrence No. 2 trends N67W, 68N. This mineralized area is 50 ± 5 feet (15 ± 1.5 m) southwest of a 4 ± $^1/_2$ foot- (120 ± 15 cm) thick oolitic bed, but there are several, less prominant oolitic beds.

Occurrence No. 3, exposed during 1963, consisted of about 50 pounds (20 kg) of galena, and just northwest of the galena, an 18 × 24 inch (46 × 60 cm) mass of tetrahedrite (L. J. Duersmith, personal commun., 1972). In addition to the above, Duersmith recognized malachite, azurite, bornite, pyrite, anglesite, and rare native silver wires at occurrence No. 3. Golden calcite scalenohedrons up to 10 pounds (5 kg) each were recovered from a pocket about 200 feet (60 m) southeast of the galena. Duersmith reported that the quarry had levels at 60 feet (18 m), 110 feet (34 m), 140 feet (42 m), 170 feet (52 m), etc.

Magnetite sand near the diabase dike was reported by Frazer (1880, p. 34-35). He concluded that it was the result of selective weathering and accumulation from normal diabase. Duersmith, on the other hand, found a single mass of partly disintegrated magnetite weighing approximately 500 pounds (200 kg) just southeast of the dike (Figure 8). Diamond core drilling begun about 350 feet (110 m) southeast of occurrence No. 1 encountered diabase at 11 feet (3.4 m) and stayed in it to 87 feet (26 m). No magnetite was encountered. This magnetite may represent Cornwall-type mineral-

ization. Although unlikely, a genetic connection between the magnetite and tetrahedrite-galena occurrences is possible. Magnetometer traverses across the dike in the area of Figure 8 might be used to search for small contact metasomatic-hydrothermal lead-silver-copper deposits. The presence of lead, silver, copper, and bismuth in three occurrences along bedding suggests, however, that the magnetite and base metals are unrelated and that Wise's (1960) belief in the structural importance of the Conestoga-Vintage contact in localizing lead-silver mineralization at Pequea, may apply at Billmeyer as well. Exploration for larger, Timberville, Virginia-type deposits should also be considered.

5. BLUE BALL QUARRY, LANCASTER COUNTY

(Zinc Occurrence)

1. *Name:* Blue Ball quarry owned by the Blue Ball Stone Co., Inc. Formerly, this was the J. C. Showalter quarry.

2. *Location:* A. The Blue Ball quarry is located 1500 feet (460 m) northeast of Blue Ball, and the same distance west of the "T" of Pa. Route 897 south onto Pa. Route 23, East Earl Township, Lancaster County. The quarry rim is at an elevation of about 475 feet (146 m).

B. LATITUDE N: 40° 07′ 18″ LONGITUDE W: 76° 02′ 14″

C. TOPOGRAPHIC MAP: New Holland $7\frac{1}{2}$-minute quadrangle.

3. *Host Rock:* Jonas and Stose (1926) mapped the quarry area as Cambrian Elbrook Formation, whereas Haefner (1972) indicated that the rock was the Snitz Creek Formation. The latter is presently considered to be the basal formation of the Conococheaque Group of Upper Cambrian age. The sandy soil favors the Snitz Creek Formation interpretation.

4. *Estimated Amounts of Ore Metals:*

$<$1 g:
1-1000 g: Pb, Ag, Ti
1-1000 kg: Cu (low end of range)
$>$1000 kg: Zn

5. *Minerals Observed and Relative Amounts:*[1]

A. ECONOMIC

Major:

Minor: Sphalerite (yellow-gray to black disseminated, yellow to dark-brown crystals, and cadmium-sulfide-yellow color on fractures), and chalcopyrite (some tetrahedra). See Figure 9.

1. Lapham and Geyer (1969 and personal commun., 1974) observed analcime, celestine, feldspar, fluorite, hematite, malachite, rutile, and strontianite elsewhere in the quarry. Haefner (1971) describes their occurrence. Bryon Brookmeyer (personal commun., 1975) has also collected gypsum var. selenite with micro-rutile crystals from the lower level of the quarry.

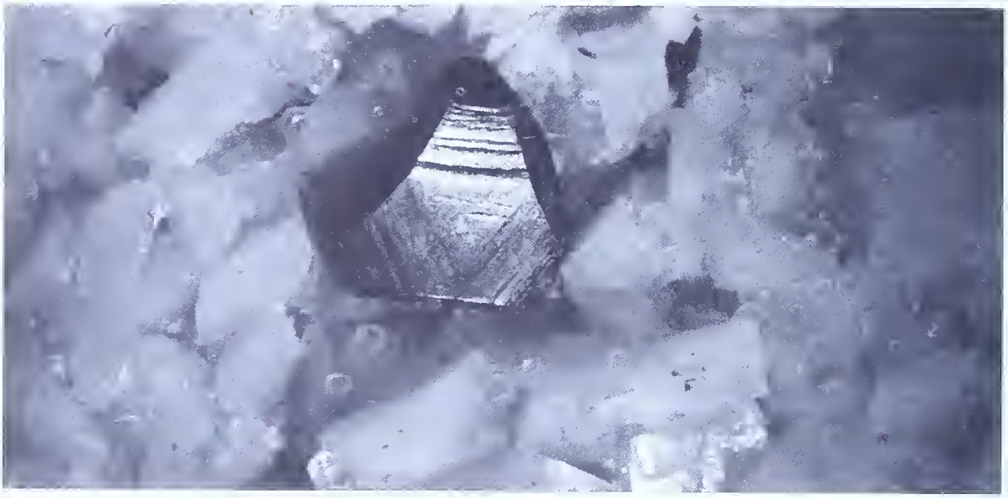


Figure 9. Sphalerite crystal (⅜ inch, 10 mm) on dolomite, Blue Ball, Lancaster County. (Specimen (B. Brookmyer) and photo (Col. Thomas Myers) courtesy of Friends of Mineralogy, Pennsylvania Chapter.)

Trace: Galena, native silver (micro-wires on dolomite near chalcopyrite. Verified by X-ray fluorescence).

B. GANGUE

Major: Quartz, dolomite (white to pink cleavages and crystals)
Minor: Pyrite, calcite
Trace: Muscovite, var. sericite (small flakes on partings)

6. *Paragenesis:* Quartz, dolomite and sphalerite; chalcopyrite, calcite and pyrite. A bright-yellow sphalerite occurs in thin, late fractures. Based on the curved cleavage, the larger sphalerite cleavages have probably been deformed.

7. *Geologic Description:* The Blue Ball quarry is probably located on the north limb of an anticline where bedding is estimated to strike about N80E and dip about 10°-15° to the north. The map of Jonas and Stose (1926) and the map based upon it edited by Gray and Shepps (1960) indicate that the region is extensively faulted. Haefner (1972) and Hirnisey and Haefner (1965) report a set of north-northwest trending faults which they believe to be Triassic in age. Lanning (1972) mapped a Triassic olivine tholeiite dike to within 1.1 miles (1.8 km) north of the quarry. Because the dike may follow a Triassic structure, a Triassic age for some of the structure in the quarry is also reasonable despite the quarry being 2.3 miles (3.7 km) south of the present margin of the Triassic basin. Also, erosional remnants of a thin veneer of Triassic sediments are still preserved a short distance to the northeast of the quarry (north of Goodville). Smith (1973) reported unusually high contents of lead and chlorine for primitive olivine tholeiite of the same type as at Blue Ball. Although unlikely, a genetic connection between the diabase dikes and base metal mineralization is thus possible. The analcime reported by Lapham and Geyer (1969) and

Haefner (1972) also could be related to hydrothermal solutions initiated by diabase, but Precambrian basement, probably occurring at moderately shallow depths, is an alternate source.

A memo in the Pennsylvania Geologic Survey files, probably written by D. M. Lapham and A. R. Geyer (circa 1960), describes the geology as follows:

> Conococheague(?) limestone strikes N.E. and dips about 25NW. The upper limestone beds are shaly and thin bedded. The limestone at the northeastern end of the quarry and below the shaly limestone is more massive. Several normal and bedding plane thrust(?) faults are visible. The limestone is highly fractured, the fractures being calcite-filled. Calcite-feldspar and quartz veins and pods are largely parallel to bedding. Bedding-plane rolls have resulted in numerous slickensides.

It was only possible to visit the quarry with a group of mineral collectors and examination of the quarry walls was not permitted because of safety restrictions. Freshly blasted float indicated a bed or beds greater than 1-foot (30 cm) thick which contained an estimated 0.1 to 1% Zn. This bed was a marble-like, mottled light- to medium-gray, finely crystalline dolomite. Float distribution suggested that mineralization was concentrated in the central to northeast portions of the now inactive, lower level of the quarry. Although the more spectacular sphalerite crystals occur along fractures and faults, the economically more interesting, disseminated sphalerite appeared to occur in a distinct bed or beds and is therefore visually strataform. No galena was observed with the disseminated sphalerite, which in general resembles that from the Bamford area. Haefner (1972) reports galena about 1 inch (2.5 cm) in size, but does not describe the association.

Both the presence of sphalerite disseminated (early?) in certain beds and the trace of silver suggests that further study of the occurrence may be warranted. Determination of the trace-element content of Cambrian Vintage limonite ores from the north side of Welsh Mountain and a local, detailed stream sediment survey appears warranted.

A specimen of Bamford-Blue Ball-type sphalerite in dolomite in an old Survey collection is simply labelled "Beartown," an area a few miles southeast of Blue Ball.

6. BUSHKILL DRIVE OUTCROPS, NORTHAMPTON COUNTY

(Trace Zinc Occurrence)

1. *Name:* Bushkill Drive outcrops.

2. *Location:* A. The sphalerite-bearing outcrops are 250 feet (75 m) N38W of the intersection of Bushkill Drive with 13th Street of Easton. These outcrops are approximately 100 feet (30 m) uphill (north) from the small dolomite quarry shown on the map of Drake (1967) along the north-northeast side of Bushkill Drive, 250 feet west-northwest of its intersection

with 13th Street. The chalcopyrite-bearing outcrop is on the northwest end of the dolomite quarry where the quarry has been cut off to accommodate an unimproved road to the northwest, relocated for the widening of Bushkill Drive through Chestnut Hill. The chalcopyrite-bearing outcrop is approximately 375 feet (115 m) west-northwest of the intersection of Bushkill Drive and 13th Street. Both the sphalerite and chalcopyrite-bearing outcrops are within the Easton city limits, Northampton County.

B.	LATITUDE N	LONGITUDE W
Zn-bearing outcrop	40° 41′58″	75° 13′45″
Cu-bearing outcrop	40° 41′57″	75° 13′46″
Dolomite quarry	40° 41′57″	75° 13′45″

C. TOPOGRAPHIC MAP: Easton 7½-minute quadrangle.

3. *Host Rock:* Drake (1967) mapped the area as dolomite of the Leithsville Formation which Drake (1969) considers to be of Middle(?) Cambrian age. If the unit is about 1,000 feet (300 m) thick, then the mineralization occurs near the middle of the formation. One 11-inch- (28 cm) thick bed of edgewise conglomerate observed in the east face of the quarry, however, suggests the upper part of the unit.

In the three locations along Bushkill Drive, the Leithsville Formation is a very thick bedded, homogeneous, finely-crystalline dolomite. Where it is not brecciated, the mineralized beds contain sparser "eyes" of white, coarsely crystalline quartz crystals up to ¼ inch (0.5 cm) which grew toward the calcite center of the eye. The Leithsville Formation in the mineralized outcrops and small quarry is less sericitic than that observed by the author in Lehigh County or the Tomstown Formation, with which the Leithsville is roughly equivalent, in Cumberland County.

4. *Estimated Total Amounts of Ore Metals:*
   - $<$1 g:
   - 1-1000 g: Cu
   - 1-1000 kg: Zn
   - $>$1000 kg:

5. *Minerals Observed and Relative Amounts:*

A. ECONOMIC

	Sphalerite outcrop	Chalcopyrite outcrop
Major:		
Minor:	Sphalerite (orange-brown)	Chalcopyrite
Trace:	Smithsonite, malachite, aurichalcite(?), chalcopyrite	Malachite, sphalerite(?)

B. GANGUE

Major:	Calcite (coarse, white)	Pyrite, calcite
Minor:	Muscovite var. sericite, quartz	Quartz
Trace:	Pyrite, pyrrhotite(?)	Dolomite

6. *Paragenesis:* Rock dolomite, quartz rim of eyes, calcite core of eyes, brecciation; calcite, pyrite, chalcopyrite and sphalerite in fractures. The age relations of the last three minerals are particularly uncertain.

7. *Geologic Description:* According to cross section D-D′ of Drake (1967), the mineralized outcrops occur at approximately the middle of the upright Leithsville Formation above a steeply south-dipping segment of the Musconetcong fault. In general, the Musconetcong fault separates the crystalline core of Chestnut Mountain from the synform of Leithsville dolomite wrapped around it on three sides.

Attitude of bedding at the chalcopyrite-bearing outcrop is rather variable because of small faults and minor brecciation, but has a median trend of N80E, 25S. Attitude of bedding in the small quarry is rather constant at N76E, 46S. The sphalerite-bearing outcrop is very near the Musconetcong fault and the bedding was estimated to strike approximately E-W and dip 30±10S.

Although the dolomite breccia is weathered and leached, it appears that the richest mineralization is near the Musconetcong fault, whereas none was observed in the small quarry. The Musconetcong fault has probably controlled the mineralization in the Leithsville dolomite. Sphalerite also occurs in Franklin marble several hundred feet northwest of the small quarry. However, widespread traces of sphalerite in the Franklin Formation suggest that the sphalerite in this host may be unrelated. Another possibility is that sphalerite has been mobilized from the Franklin into the Leithsville Formation (A. W. Rose, personal commun., 1976). Trace-element analyses of these sphalerites may demonstrate the relationships.

This location was furnished to the author by Charles Van Ness who found it while a student at Lehigh University.

7. CAMBRIAN MANGANESE-BEARING LIMONITES FROM THE SOUTH MOUNTAIN ANTICLINORIUM, CUMBERLAND COUNTY

(Iron And Manganese Ores, Geochemically Anomalous For Zinc-Lead)

1. *Name:* Reading (Beltzhoover) Banks, Wharton mine, and Laurel No. 1 Bank. Neighbors report that Reading Banks is owned by the U. S. Steel Corporation, but this has not been verified. Laurel No. 1 Bank is on Pennsylvania State Forest Lands.

2. *Location:* A. Reading (Beltzhoover) Banks is located on the north side of South Mountain at an elevation of about 580 feet (177 m), 1.5 miles (2.4 km) southeast of Boiling Springs, and 2.55 miles (4.1 km) southwest of Churchtown (Allen P.O.), Monroe Township, Cumberland County. Foose (1945, p. 74-75) equates Reading Banks with Ege Bank (Big Bank), the largest and most manganese-rich deposit. E. V. d'Invilliers, who visited the active mines, however, (1883, p. 1467, 1470, and map 8) shows that the Ege Bank is 3700 feet (1100 m) southwest of Reading Banks.

Wharton mine was found to be located on the north side of South Mountain at an elevation of 760 feet (232 m), 1.80 miles (2.85 km) southwest of Mount Holly Springs and 1.2 miles (1.90 km) northwest of the 1504-foot-(458.42 m) crest of Mount Holly, Dickinson Township, Cumberland County. Foose (1945, p. 90) states that the Wharton mine "is on the western side of a topographic reentrant, or valley, which heads south into South Mountain. . . ." Stose's (1953) map likewise locates a manganese-phosphorus prospect on the west side of a small valley. However, discussion with local residents involved in the actual mining operations suggest that the previously reported locations for the Wharton mine are probably incorrect.

Wharton No. 1 Bank may be the one on South Mountain at an elevation of 770 feet (235 m) just south of Old Railroad Road, 0.45 mile (0.7 km) northeast of Laurel Forge Pond, 0.65 mile northeast of Pole Steeple, Dickinson Township, Cumberland County. It is also possible that this pond could be Laurel Bank No. 2, as the map of d'Invilliers (1883) is not very detailed.

B.	LATITUDE N	LONGITUDE W
Reading (Beltzhoover)	40° 08′ 01″	77° 06′ 34″
Wharton	40° 06′ 26″	77° 13′ 20″
Laurel No. 1	40° 02′ 30″	77° 15′ 45″

C.	7½-minute Topographic Quadrangle
Reading (Beltzhoover)	Mechanicsburg
Wharton	Mount Holly Springs
Laurel No. 1	Dickinson

3. *Host Rock:* As described by Foose (1945, p. 76), the Mn-bearing limonite at Reading Banks occurs in a clay zone which probably corresponds to the base of the Cambrian Tomstown (≅Vintage) dolomite and perhaps the top of the Cambrian Antietam quartzite.

Foose (1945, p. 90) reported that the Wharton mine ". . . occurs in a weathered part of the Antietam sandstone, and high enough on the mountain so that the horizon may be toward the middle of the Antietam." However, the correct location of the Wharton mine is just below the pronounced break in slope such that the host is probably lower Tomstown Formation.

Foose (1945, p. 91) reports that the Laurel Banks were in ". . . tan residual clay of the basal Tomstown formation." This is partly confirmed by Tomstown dolomite blocks found on the dumps. Freedman (1967) and Hosterman (1969) would probably describe the quartzite beneath the ore as Mont Alto Member of the Harpers Formation.

4. *Estimated Total Amounts of Ore Metals:*

A.	Reading (Beltzhoover)	Wharton	Laurel No. 1
<1 g:			
1-1000 g:			
1-1000 kg:	Zn, Pb	Fe, Zn, Co	Zn
>1000 kg:	Fe, Mn	Mn, P	Fe, Mn

B. ASSAYS (in ppm unless noted):[1]

	Co	Ni	Cu	Zn%	As	Ag	Pb	Mn%	Sample size
Reading (Beltzhoover)	150	165	90	.21	45	<.1	400	9.8	232 1" chips
Wharton	940	355	350	.21	5	<.1	40	25.0	306 ½" chips
Laurel No. 1	335	160	130	.24	5	<.1	40	11.6	101 1" chips

5. *Minerals Observed and Relative Amounts:*

A. ECONOMIC

	Reading (Beltzhoover)	Wharton	Laurel No. 1
Major:			
Minor:	Pyrolusite* (soft, sooty), cryptomelane	Pyrolusite, cryptomelane* (hard, nodular)	Crytomelane*,
Trace:			Nsutite* (extremely hard, whitish-grey, metallic), pyrolusite*

B. GANGUE

	Reading (Beltzhoover)	Wharton	Laurel No. 1
Major:	Limonite, goethite (black, shiny, mammilary)	Wavellite (white, radial and crystals)	Limonite
Minor:			
Trace:	Lepidocrocite (red, fibrous)	Limonite	Lepidocrocite (red, fibrous)

6. *Paragenesis:* Unknown, all minerals described are believed to be supergene. In general, the manganese minerals occur in and cut across limonite, suggesting they are younger. The wavellite at the Wharton mine may be young.

7. *Geologic Description:* These three Mn prospects are on the South Mountain anticlinorium. This northeast-plunging anticlinorium has a core of Precambrian Catoctin metavolcanics over which are draped multiply-deformed Cambrian sedimentary rocks (Root, 1970). Root (1970, p. 825-826) believes that South Mountain is detached and that the decollement is probably within subhorizontal shaly carbonates of the Elbrook Formation at a depth of about 4 to 5 miles (6.5 to 8 km).

Although none of these manganese prospects is known to contain zinc minerals or ore-grade zinc in limonite, they are discussed here because zinc

* asterisk refers to all samples verified by X-ray powder diffraction analyses

1. See Appendix II of this report on limonites from southeastern Pennsylvania for less interesting assays of samples from the same area.

and lead minerals have been observed at the same stratigraphic horizon in York and Lancaster Counties, because economic zinc mineralization occurs in the Shady dolomite in Virginia and elsewhere,[2] (in Pennsylvania this is the Zullinger Formation of the Conococheague Group) and because some of the occurrences are on pronounced faults and lineaments. Zinc contents of 0.2% in limonite from Beekmantown Group dolomites have stimulated zinc exploration in eastern Pennsylvania. Although some other limonite occurrences in this area are high in Mn and contain only 0.06 to 0.11% Zn, a zinc content of 0.2% in Mn-rich limonite may or may not indicate zinc mineralization. Instead, it may merely reflect a difference in ground-water movement or an effect of Eh and pH on manganese's ability to absorb zinc and other trace elements.

Reading (Beltzhoover) Banks were described in detail by Foose (1945). Foose noted that the dip of bedding at Reading Banks is about 10NW. Ore observed by the author dipped a few degrees steeper to the north than this, but the plastic clay matrix could be slumped. Root (1970, p. 823) interprets the fault passing through Reading Banks (Stose, 1953) as a steeply southeast-dipping thrust. The lead content of 400 ppm is high for any limonite with or without manganese minerals. For example, the geologically similar White Rocks manganese pit limonite from 3700 feet (1200 m) to the east contains only normal amounts of zinc (0.11%) and lead (30 ppm).

The Wharton mine lies between the Laurel Forge and Cold Springs thrust faults (Stose, 1953). Root (1970, p. 823) believes that the Laurel Forge fault is a subvertical, east-dipping, normal fault. If Root's interpretation of the fault is correct, mineralization is probably unrelated to this structure. The cobalt content or ore from this prospect is quite high, nearly 0.1%. Wavellite is very common, however, and this phosphorus mineral has detracted from an otherwise good-grade manganese (25% Mn) occurrence.

The Laurel No. 1 Bank is probably along a steep fault contact between Tomstown dolomite and a quartzite, based on extrapolation of the map of Freedman (1967). From the description of the Crane bank by d'Invilliers (1883, p. 1461), who apparently entered the mine when active, this fault is ". . . apparently dipping at a very steep angle *into* the hillside *northward*. . . ." Root (1970) and Freedman (1967), however, mapped the fault as south dipping. Float of Tomstown dolomitic limestone occurs in a *small* pit on the west side of the pond. E. V. d'Invilliers (1883, p. 1450-1453) notes that the dip of ore in the mine was predominantly to the southeast.

2. In the Linganore district near Frederick, Maryland (Heyl and Pearre, 1965), manganese oxides have formed from the weathering of manganoan calcite gangue associated with copper, lead, and zinc sulfides and in the Embreeville district in northeast Tennessee (Rodgers, 1948) manganese and iron oxides occur from the weathering of pyrite and manganoan-dolomite which are associated with the lead and zinc sulfides in the Shady dolomite (equivalent to the Cambrian Tomstown Formation of Pennsylvania).

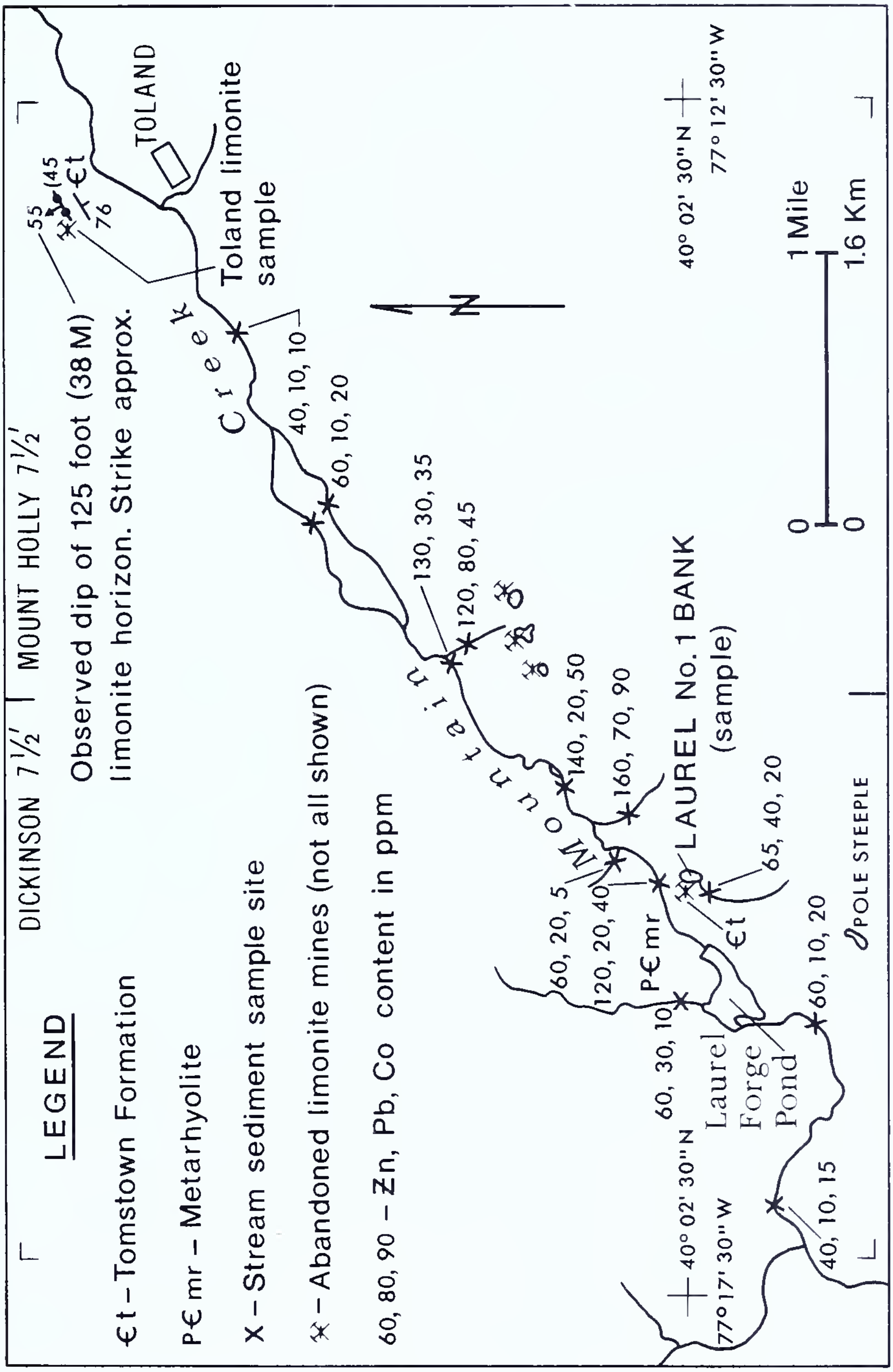


Figure 10. Location and stream sediment geochemical data map for Laurel Banks area along Mountain Creek, Cumberland Co.

This author believes that metarhyolite (and minor metabasalt) may extend farther east than shown by the map of Gray and Schepps (1960). The metarhyolite contains phenocrysts of orthoclase(?) and is sufficiently pink to suggest that it may contain piemontite. This latter mineral, a manganese-epidote, could have been a source for manganese in the Laurel No. 1 Bank location.

Stream sediment data for zinc, lead, and cobalt are plotted on Figure 10. The samples with the highest zinc, lead, and cobalt probably drain areas of manganese-rich limonite occurrences and interpretation is therefore difficult. In the Philadelphia Clay Co. pit (Medusa) a limonite sample referred to as "Toland" was collected. It contains only 640 ppm Zn, 20 Pb, and 210 Co. The presence of alunite, $KAl_3(SO_4)_2(OH)_6$, and the chemical profile with depth led Hosterman (1969) to conclude that the clay deposit was probably formed in part by hydrothermal alteration. Despite the general opinion of genuine experts, the author is not personally convinced of a hydrothermal origin for all alunite, but the presence of a sulfur-bearing mineral is strongly suggestive of the possible former presence of sulfide minerals in the vicinity.

8. GAP NORTHEAST ZINC PROSPECT, LANCASTER COUNTY

(Zinc Occurrence)

1. *Name:* The Gap Northeast zinc prospect (appears to have been on the Elam Stoltzfoos farm adjacent to the Omar Stoltzfoos farm).

2. *Location:* A. The prospect is located in a tiny, abandoned quarry approximately 150 feet (50 m) west of an unnamed tributary flowing north to Pequea Creek. This quarry is 1.1 miles (1.75 km) south of Pequea Creek, 0.85 mile (1.35 km) north of the junction of Pa. Route 897 and U. S. Route 30, and 1.7 miles (2.7 km) southeast of Buyerstown, Salisbury Township, Lancaster County (Figure 11). Substantial soil geochemical anomalies are reported 700 feet (215 m) and 4000 feet (1200 m) southwest of the quarry (McKelvey, 1966).

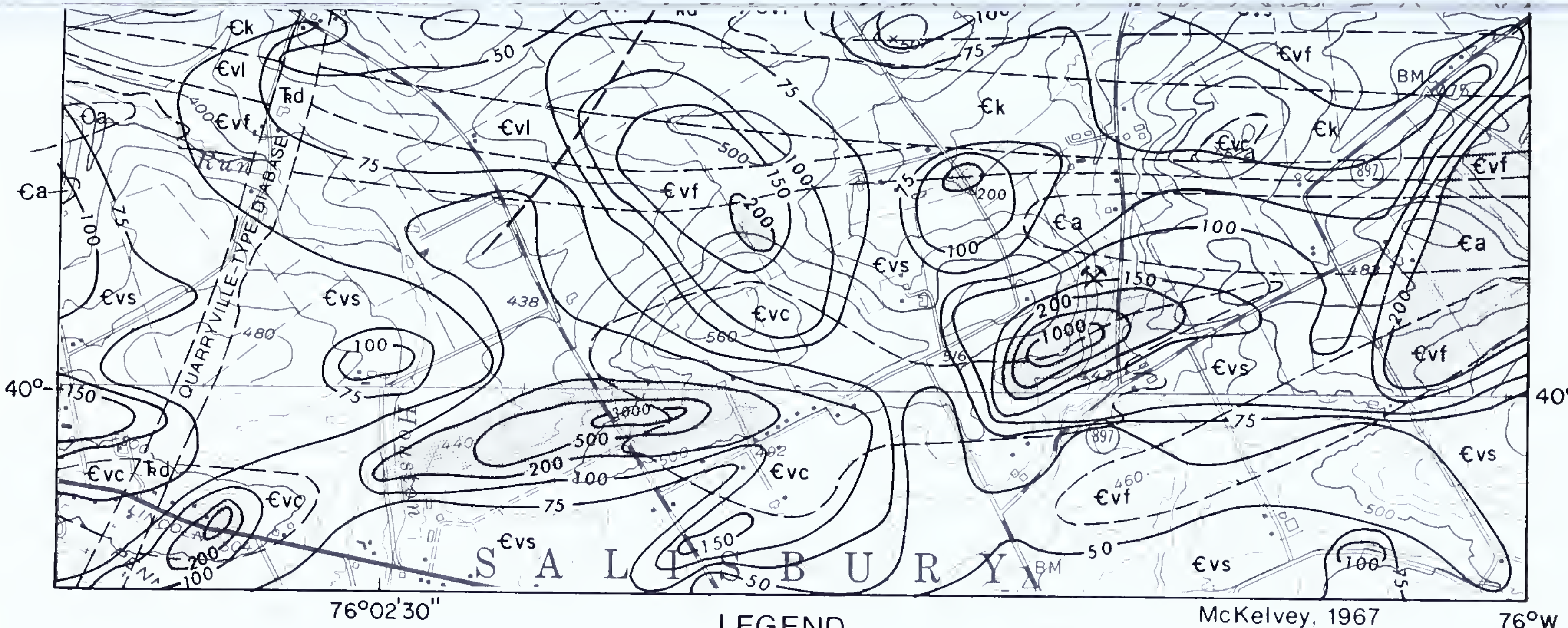
B.

	Tiny Quarry[1]	1000 ppm Geochemical Anomaly	3000 ppm Geochemical Anomaly
LATITUDE N:	40° 00′ 11″	40° 00′ 06″	39° 59′ 58″
LONGITUDE W:	76° 00′ 58″	76° 00′ 59″	76° 01″ 53″

C. TOPOGRAPHIC MAP: New Holland 7½-minute quadrangle.

3. *Host Rock:* Cambrian Vintage dolomite, ". . . a white, finely crystalline dolomite, interlayered with numerous, very thin phyllitic layers composed of muscovite, biotite and locally chlorite" (Freedman, 1972, p. 43).

1. Approximate because of map loss in the June, 1972 flood.



LEGEND

TRd - Triassic diabase (dike)

CAMBRIAN

ꞒK - Kinzers Formation, interbedded limestone and dolomite with local shale layers

Vintage Dolomite

- ꞒVl - Interbedded limestone and dolomite with local shale layers
- ꞒVf - Light-blue, fine-grained dolomite with some phyllitic layers
- ꞒVs - Dolomite, sparkling white ta dull, fine-grained dolomite with phyllitic layers and impregnated with sulfides
- ꞒVc - Schist, quartz-biotite with local mineralization

Ꞓa - Antietam Schist, including quartz-biotite schist

—— 75 ——

—— 100 ——

Contours for cancentrations af zinc, in parts per million (Cantour interval variable)

— — — — —

Contact (Dashed where probable)

⚒ Prospect

SCALE

0 — 2000 feet

0 — 620 meters

Figure 11. Zinc content of soils in Gap Northeast prospect area (Freedman, 1972).

4. *Estimated Total Amounts of Ore Metals:*

A.

	Tiny Quarry	Area of Geochemical Anomaly[3]
<1 g:		
1-1000 g:	Cu, Pb, Zn[2]	
1-1000 kg:		Zn
>1000 kg:		

B. ASSAYS: The author's visual estimate of the richest hand samples from the quarry is less than 0.5% total Pb, Zn, and Cu. However, Greg McKelvey (in Freedman, 1972) found a 1000 ppm Zn soil anomaly 700 feet (215 m) to the south-southwest and a 3000 ppm (0.3%) Zn anomaly 5000 feet (1500 m) to the west-southwest of the quarry. Selected rock samples collected by A. V. Heyl (personal commun., 1976) from the area of the 1000 ppm Zn soil anomaly assayed 1% Zn.

5. *Minerals Observed and Relative Amounts:*

A. ECONOMIC

Major:
Minor:
Trace: Sphalerite,[4] chalcopyrite, galena,[5] malachite

B. GANGUE

Major: Dolomite, quartz
Minor: Pyrite (cubic), "limonite"
Trace:

6. *Paragenesis:* Freedman (1972) observed that sulfides have grown across the sheared, oriented micaceous minerals, and therefore concludes that sulfide mineralization occurred after deformation.

7. *Geologic Description:* As mapped by S. Curran and J. Gucwa (Freedman, 1972), the area consists of complexly folded Kinzers limestone, dolomite, and shale, Vintage dolomite, and Antietam schist, all of Cambrian age (Figure 11). Apparent bedding in the quarry strikes N80E and dips 88N.

As shown by Curran and Gucwa, the area 1.6 miles (2.6 km) to the west of the quarry is cut by a Triassic diabase dike. Lanning (1972) mapped this dike as Quarryville-type olivine normative tholeiite. Lanning also mapped a sizable Rossville-type dike, missed by Curran and Gucwa, 1.2 miles (1.9 km) west of the quarry. The southern end of this Rossville-type dike corresponds closely with the strongest copper anomaly found by Freedman in this area. Rossville-type diabase dikes are spatially associated with Cu mineralization at Billmeyer and Rossville.

2. Above estimate based on near invagination of the outcrop by two collectors for four hours.
3. A. V. Heyl (personal commun., 1976).
4. A. V. Heyl first observed and collected colorless to gray sphalerite at the site of the 1000 ppm Zn soil anomaly.
5. Chalcopyrite is approximately 5 times as abundant as galena.

The mineralization in the quarry itself does not warrant further investigation; however, the zinc geochemical anomalies, found by Greg McKelvey (1966) to the south and southwest may.[6] Agricultural zinc additives and the intentional collecting of organic-rich samples may have contributed to some of the anomalies, but the sphalerite found in outcrop by Heyl could be leakage from a larger occurrence.

6. During re-examination on 5/27/77, a mineralized outcrop was found approximately 300 feet (90 m) S20W of the tiny quarry. The outcrop contains minor galena, sphalerite, chalcopyrite, and pyrite in an impure micaceous finely crystalline dolomite. Foliation in the outcrop trends approximately E-W and dips 70S.

9. KLINE'S QUARRY, YORK COUNTY

(Minor Zinc Occurrences)

1. *Name:* Kline's quarry is owned by Richard and Edmund Kline.

2. *Location:* A. Kline's quarry is located 0.55 mile (0.9 km) south of the west end of the Columbia-Wrightsville bridge in Wrightsville. This is 0.35 mile (0.6 km) southwest of the junction of Kreutz Creek and the Susquehanna River and at an elevation of about 250 to 350 feet (75 to 110 m). The quarry is expanding southwest, perhaps to beyond the Wrightsville borough boundary into Hellam Township, York County.

B.

	Vintage Formation	Antietam-Harpers Formation
LATITUDE N:	40° 01′ 04″	40° 01′ 02″
LONGITUDE W:	76° 31′ 26″	76° 31′ 30″

C. TOPOGRAPHIC MAP: Columbia West 7½-minute quadrangle.

3. *Host Rock:* Two Cambrian formations, both mineralized, are exposed in Kline's quarry: dolomite of the Vintage Formation and quartz phyllite of the Antietam-Harpers. The Vintage dolomite contains sphalerite 5 feet (1.5 m) stratigraphically above the uppermost quartz phyllite bed of the Antietam-Harpers Formation (see report on North Manor Hill p. 54). The mineralization in the Antietam-Harpers Formation occurs on upper levels of the quarry from which measurement to the contact with the Vintage is not practical. This mineralization is estimated to occur about 100 to 200 feet (30 to 60 m) stratigraphically below the Vintage Formation.

4. *Estimated Total Amounts of Ore Metals:*

	Vintage Formation	Antietam-Harpers Formation
<1 g:	Pb, Cu	
1-1000 g:		
1-1000 kg:	Zn (low end of range)	Zn, Pb, Cu, Ti
>1000 kg:		

5. *Minerals Observed and Relative Amounts:*[1]

		Vintage Formation	Antietam-Harpers Formation
A. ECONOMIC			
	Major:		Sphalerite (reddish- to dark-golden-brown)
	Minor:	Sphalerite (dark-golden-brown)	Galena* (some with octahedral cleavage or parting), chalcopyrite
	Trace:	Galena, chalcopyrite	
B. GANGUE			
	Major:	Pyrite (cubes; elongated cubes; and concentric, radial), dolomite (white)	Pyrite (cubes modified by octahedral faces in vugs and phyllite), quartz (milky and colorless crystals), pyrrhotite
	Minor:	Muscovite var. sericite (fibers)	Anatase[2] (blue crystals), brookite* (golden-brown crystals), albite (cleavages and prismatic white crystals), chalcopyrite, "chlorite"* (with Fe: Mg about 3:2), ilmenite, dolomite, hematite
	Trace:	Quartz, rutile	Marcasite,[3] orthoclase var. adularia,[4] rutile,[4] monazite* (golden-brown, tabular) calcite

6. *Paragenesis:* For mineralization in Vintage: rock dolomite, white crystalline dolomite, muscovite var. sericite, pyrite, sphalerite; quartz, galena and chalcopyrite. There is some very late pink dolomite and calcite,

1. Elsewhere in the quarry, aragonite, goethite, graphite,* and biotite have been found (M. L. Anné, personal commun., 1974).
2. Dipyramids with variable development of basal pinacoid.
3. Confirmed by Dr. Raymond W. Grant, Lafayette College, by X-ray diffraction.
4. Reported by A. Montgomery (1973).

but not directly associated with sphalerite or galena. The paragenesis for all of these minerals is very uncertain.

For mineralization in Antietam-Harpers: quartz, dark sphalerite, albite, pyrite and calcite, with some overlap between the last two. It is also known that marcasite is younger than galena; that anatase and brookite replace ilmenite; and that chlorite coats (i.e., is younger than) ilmenite. Chlorite seems to be most closely associated with brookite and rutile. The paragenetic sequence of the other minerals is unknown at present, but there may be several distinct stages. Montgomery (1973) observed rutile crystals on anatase.

7. *Geologic Description:* Kline's quarry is located on the north, vertical limb of the North Manor Hill or Strickler anticline. Mineralization occurs within a few hundred feet of the contact of Vintage dolomite with Antietam-Harpers quartzose phyllite, making the occurrence somewhat similar to the North Manor Hill sphalerite occurrence, just across the Susquehanna River. Unlike the situation there, the apparent contact between the Vintage and the Antietam-Harpers at Kline's quarry is gradational with repetition of carbonate and clastic beds over tens of feet. Possible bedding plane thrusts may have modified the contact at one or both localities. Stose and Jonas (1939) mapped the Cambrian clastics at Kline's quarry as Antietam quartzite. Montgomery (1973) refers to the host as Harpers phyllite based on discussions with geologist Leonard J. Duersmith. Because this rock contains 60-70% SiO_2, is just below the Vintage Formation as the Antietam should be, and contains only minor amounts of mica and chlorite, the author prefers "Antietam-Harpers." However, some of the rock does have a phyllitic cleavage, justifying the Harpers suffix.

Stose and Jonas (1939) mapped the Vintage-Antietam contact 0.8 mile (1.3 km) west of Kline's quarry as being a fault contact. No major faults were, however, observed in Kline's quarry. Meisler and Becher (1971) characterize the geology east of Kline's quarry as an area of steep, isoclinal folding.

Bedding near the sphalerite in Vintage occurrence (60 feet or 18 m south of the cave in the east wall) is N77E, 77S or slightly overturned. Bedding near the sphalerite, galena, etc. in Antietam-Harpers is N77E, 83S.

The sphalerite in Vintage occurs in bed-parallel pyrite veins which are about ½ inch (1.3 cm) wide and 5 inches (13 cm) long. The dolomite host here contains 10-30% coarse crystalline, white dolomite.

The mineralization in the Antietam-Harpers is of two related types. The first occurs in milky quartz pods, generally about 10 to 12 inches (25-30 cm) thick, about 20 to 50 feet (5 to 15 m) long, and dipping approximately 30S. They are parallel to strike, but cut across the dip. Sulfide minerals are confined to a discontinuous band of sulfides in blebs about ½ inch (1 cm) from the upper contact. The sulfide blebs (consisting of pyrrhotite, galena,

and minor chalcopyrite) are mostly $^1/_{16}$ to $^1/_2$ inch (2 mm to 1 cm) in size. Anatase, chlorite, etc. generally occur in reaction zones, not everywhere present, between the quartz pods and the county rock. The second type of mineralization in Antietam-Harpers also occurs along hairline fractures which commonly open into small vugs. This type of mineralization more often contains red-brown sphalerite, calcite, pyrite, and albite.

The mineralization in Kline's quarry has probably been localized in open spaces generated by deformation of rocks with differing competences. The disseminated pyrite crystals in the Antietam-Harpers could have been a factor in supplying sulfur or reducing these solutions.

The galena in the quartz pods at Kline's quarry has an octahedral cleavage, or parting, in addition to the usual cubic one. This, in addition to its occurrence in quartz veins along dolomite-phyllite contacts and accessory titanium minerals, suggests a similarity with the Burnt Mills-Pequea occurrences. The trace sphalerite and galena occurrence at the Safe Harbor quarry, Lancaster County (Chapman, 1950), appears to be of the same type. Some of the galena from Pequea is high in silver, and assays of galena from the quartz pods at Kline's should be interesting.

The Kline's quarry sulfides are of no direct economic significance, but suggest that the Vintage (Tomstown) dolomite could be a suitable economic host. The area around the South Mountain anticlinorium seems favorable for zinc deposits along the contact between the dolomite and quartzite.

10. MEDUSA WEST YORK QUARRY AND YORK AREA, YORK COUNTY

(Trace Zinc Occurrence)

1. *Name:* Medusa West York quarry owned by Medusa Portland Cement Company.

2. *Location:* A. The quarry is located in the area bounded by U. S. Route 30 Bypass, Pennsylvania Routes 234 and 74, and Baker Road, Manchester Township, York County. The quarry is 1.5 miles (2.4 km) south of Shiloh, 2.0 miles (3.2 km) east-northeast of Pa. Route 234 over Honey Run, and 2500 feet (750 m) northeast of the overpass of Pa. 234 over U. S. Route 30 Bypass.

B. LATITUDE N: 39° 57′ 21″ LONGITUDE W: 76° 47′ 36″

C. TOPOGRAPHIC MAP: West York $7^1/_2$ minute quadrangle.

3. *Host Rock:* Cambrian Kinzers Formation. The map and text of Stose and Jonas (1939) indicate that the Medusa quarry is in the middle member of the Kinzers, here a moderately high-calcium (85 ± 5% $CaCO_3$) limestone. They state that this is underlain by a lower member of black to dark-gray shale and overlain by an impure, sandy member. Much of the middle member is white, crystalline limestone with a vague "conglomeratic" texture resulting from lenticular pure white limestone in a slightly gray groundmass.

4. *Estimated Total Amounts of Ore Metals:*
<1 g:
1-1000 g: Pb, Ba
1-1000 kg: Zn, Cu (both low end of range)
>1000 kg:

5. *Minerals Observed and Relative Amounts:*

A. ECONOMIC

Major:	
Minor:	Sphalerite (clear, colorless to yellow to gray to black in tetrahedra and complex twins)
Trace:	Chalcopyrite (tetrahedra), bornite,* aurichalcite, wurtzite,[1] galena, azurite,[1] malachite (clear, emerald-green twinned crystals and fibrous tufts)

B. GANGUE

Major:	Calcite (clear, colorless scalenohedrons and complex crystals)
Minor:	Dolomite (cream-colored crystals)
Trace:	Pyrite (cubes), marcasite,* hematite (crystalline plates), barite* (spheres of white tabular crystals)

6. *Paragenesis:* Calcite; sphalerite (colorless to dark), chalcopyrite, and barite; supergene malachite and aurichalcite.

7. *Geologic Description:* The Medusa quarry is located in a complexly folded and faulted zone of carbonates between the Triassic basin to the northwest and Cambrian clastic rocks to the southeast. Stose and Jonas (1939) show the carbonate zone as the complex westward extension of the Wrightsville syncline. Within the quarry, bedding is flat lying to gently dipping. Sphalerite was not collectable directly from the dangerous quarry walls. A small fault trending N45W, 40SW, passed through the area where loose sphalerite was collected on the lower level and may have influenced sphalerite mineralization. Average bedding in the quarry is visually estimated to strike about N45E and dip gently to the northwest.

Sphalerite float was observed at two places: 1) 2700 feet (825 m) N45E (on upper level), and 2) 2175 feet (660 m) N30E (on lower level) of the overpass of Pa. Route 234 over U. S. Route 30 Bypass. On the upper level, sphalerite occurs with chalcopyrite, malachite, and rare galena in pink calcite and on the lower level sphalerite and chalcopyrite occur in clear, colorless calcite with rare barite.

Jandorf (1912) reported sphalerite and/or galena from the B. H. Stoner, York Valley Lime Company, Emigsville Quarry Company, Union Stone Company, York Stone and Supply Company (see p. 80), Hartley-Ziegler Co., M. Palmer Lime Co., and Cunningham Brothers quarries in the York area. The Stoner, York Valley, Union, and York Stone quarries listed by Jandorf as well as the White Pigment Corp. and Standard Concrete

1. Reported by Lapham and Geyer (1969), but not observed during the present study.

Products quarries were visited briefly. Sphalerite and trace galena were found only in the York Stone and Supply Company quarry, and only the north quarry has any direct economic significance.

The author believes that the best place to explore for zinc in this area probably would be in the transition to deep-water Conestoga (Lower through Upper Cambrian) facies, a few miles to the southeast. See Rodgers (1968) for a discussion of the similarity of this facies change in Pennsylvania to that in the Austinville, Virginia zinc district.

11. NORTH MANOR HILL AREA, LANCASTER COUNTY

(Minor Zinc Occurrence)

1. *Name:* The North Manor Hill sphalerite occurrence is reported to be owned by a Mr. Reish.

2. *Location:* A. The sphalerite occurs behind Mr. Reish's house about 25 feet (8 m) above the level of Pa. Route 441. This occurrence on the south side of North Manor Hill is 1200 feet (370 m) southeast along Route 441 from the Columbia borough boundary near the junction of Strickler Run with the Susquehanna River in Manor Township, Lancaster County.

B. LATITUDE N: 40° 01′ 07″ LONGITUDE W: 76° 29′ 20″

C. TOPOGRAPHIC MAP: Columbia East 7½-minute quadrangle.

3. *Host Rock:* The sphalerite occurs in dolomite of the Vintage Formation of Cambrian age 2 to 3 feet (0.6 to 0.9 m) above the contact with the underlying quartz phyllite of the Antietam-Harpers Formation. At North Manor Hill, the contact between the Vintage and Antietam-Harpers occurs in a 1-foot (30 cm) concealed interval, making the contact appear sharp. The lowest exposed bed of the Vintage is about 4 feet (1.2 m) thick and composed of gray, crystalline dolomite (marble) without the sericite common in the overlying beds. Jonas and Stose (1930, p. 24) described the impure, basal beds of the Vintage in this area as generally being cream-colored to pinkish-white, fine-grained marble, in places micaceous. Meisler and Becher (1971, p. 73-74) measured and described this section of Vintage dolomite, but their lowest interval is 26 feet (8 m) thick and their description does not fit the lowest three feet which contains the sphalerite. The Vintage at North Manor Hill contains quartz-dolomite eyes similar to those observed in the Cambrian Leithsville Formation sphalerite occurrence at Easton, Pa. (see report on Bushkill Drive outcrops).

4. *Estimated Total Amounts of Ore Metals:*

A. $<$1 g:

1-1000 g: Pb, Ag (both based only on assay below)

1-1000 kg: Zn (probably less than 100 kg)

$>$1000 kg:

B. ASSAYS: A composite of 39 one-inch chips of limonite with some pyrite collected about 30 feet (9 m) above the sphalerite was found to contain the following metals (in ppm): 100 Co, 40 Ni, 75 Cu, 1200 Zn (0.12%), 320 As, 2.2 Ag, and 880 Pb. The silver and lead contents are anomalously high.

It is estimated that the lowest 3 feet (1 m) of the Vintage may contain 0.2% Zn at this location.

5. *Minerals Observed and Relative Amounts:*

A. ECONOMIC

Major:	
Minor:	Sphalerite (lemon-yellow, disseminated and dark-brown veinlets)
Trace:	Chalcopyrite

B. GANGUE

Major:	
Minor:	Pyrite (cubes), dolomite (white)
Trace:	Quartz

6. *Paragenesis:* The disseminated pyrite and sphalerite appear approximately contemporaneous. The younger veinlets of sphalerite, pyrite, and dolomite appear approximately contemporaneous, and the chalcopyrite is the youngest of the veinlet minerals.

7. *Geologic Description:* The mineralization on the south flank of North Hill is of three types: type one consists of millimeter-sized, lemon-yellow sphalerite and pyrite blebs disseminated in dolomite; type two consists of veinlets of dark-brown sphalerite and pyrite; and type three consists of limonite replacing pyrite, mostly along an irregular joint set which trends N82E, 30N. Types one and two occur in Vintage dolomite 2-3 feet (0.6-0.9 m) above the contact with the Antietam-Harpers, whereas type three occurs 7 ± 3 feet (2 ± 1 m) above the same contact.

All of this trace mineralization is on the south limb of the North Manor Hill anticline. Meisler and Becher (1971, p. 34) note that "The anticline is isoclinal, slightly overturned to the north, and has a steep southward-dipping axial plane parallel to cleavage." They also note that this anticline is a good example of the steep isoclinal folding which characterizes a zone across the southern quarter of the Lancaster 15-minute quadrangle. The geologic map and cross sections of Meisler and Becher indicate a steeply south-dipping reverse fault cutting off the south limb of the anticline. However, it does not appear likely that mineralization is related to this reverse fault.

Bedding measured near the mineralization was N81E, 55S for both the Vintage and Antietam-Harpers Formations.

As noted above, the contact between the Vintage and Antietam-Harpers Formations appears sharp. Possibly a few thin dolomite interbeds are

concealed in the Antietam-Harpers. In contrast, in Kline's quarry, on the north limb of the same anticline just across the Susquehanna River, the contact appears gradational over tens of feet of interbedded quartz phyllites and dolomite (see the description of Kline's quarry for further details).

This occurrence was apparently first described by Jonas and Stose (1930, p. 24-25) and Miller (1934, p. 452-454) quotes their discussion. Otherwise, the occurrence is not mentioned elsewhere.[1] Still more obscure is a notice by Lesley (1856, p. 299) of a limonite sample containing cubic galena crystals from near Marietta, about 4 miles (6 km) to the northwest in an area of similar geology. However, a composite sample of limonite from one of the larger iron ore pits in the Vintage Formation near Marietta (the sampled pit is located 0.15 mile (250 m) northeast of the intersection of Routes 141 and 441 at Marietta) contained only 60 ppm Pb and 945 ppm Zn, both background values for limonite.

Because Freedman (1972, p. 45) stated that clays from nearby Grubb Lake and Mud Lake (Frazer, 1880) are anomalously high in zinc and because they occur between the North Manor Hill and Bamford zinc occurrences, it was decided to analyze limonites from these areas for zinc, lead, and other trace elements. The following results (in ppm) were obtained:

		Co	Ni	Cu	Zn	As	Ag	Pb
Mud Lake*	(40° 03′36″N, 76° 26″51″W)	195	215	135	910	10	<.1	40
Grubb Lake**	(40° 03′22″N, 76° 27′09″W)	290	335	80	1300	10	<.1	50

*50 one-inch chips **88 one-inch chips

The Grubb Lake and Mud Lake samples are not anomalously high in zinc or lead when compared with analyses of nine similar samples from this same general stratigraphic level at locations not known to contain zinc mineralization (see chapter XI). This assumes, however, that the Mud Lake and Grubb Lake deposits were on the Vintage-Antietam contact as mapped by Stose and Jonas (1930). Meisler and Becher (1971), for example, have mapped the area as possibly Ledger Formation.

Kaufman and Lowright (1962, p. 48) note sphalerite in the matrix of a specimen of Vintage dolomite from the Columbia-Mountville area. They numbered this specimen "RL-15," but the location could be either location 15 on their map, south of Columbia, or "Stop 18," southwest of Mountville, which is noted as "L-15" in their text. The present author was unable to find sphalerite at either of the two possible locations. Both areas were mapped as Vintage by Meisler and Becher, but Kaufman and Lowright mapped the Columbia location as Conestoga Formation, some of which is

1. The reference was, however, reported to Dr. Arthur Montgomery by Dr. A. V. Heyl in a personal communication dated February 1, 1965.

certainly present. The remaining possibility, southwest of Mountville, would be a poor place to prospect, because as noted by Kaufman and Lowright, the area has been obscured by a religious shrine.

In itself, the North Manor Hill sphalerite occurrence has no economic value. However, mineralization at Kline's quarry across the Susquehanna River is at a similar stratigraphic level and the Cambrian carbonates of Virginia and Tennessee contain major zinc deposits. Zinc deposits could occur in the Cambrian carbonates of Lancaster or York Counties or to the northwest surrounding the South Mountain anticlinorium. The lowest Cambrian carbonate, usually occurring above competent clastics, should be a favorable host rock for both chemical and structural reasons.

12. OLD CLIPPINGER (J. H. CRESSLER) BANK AREA, CUMBERLAND COUNTY

(Iron Ore Geochemically Anomalous For Zinc-Lead)

1. *Name:* Old Clippinger, later the J. H. Cressler bank, now owned by Dr. Thomas Smyth.

2. *Location:* A. The Old Clippinger bank is located 1.25 miles (2.0 km) west-southwest of Cleversburg, 2.05 miles (3.2 km) southeast of Shippensburg and 0.50 mile (0.8 km) northeast of Cherry Grove School and served as a source for the nearby Mary Ann Furnace (see p. 60).

Another source of iron for Mary Ann Furnace (which was reported to be incrusted with zinc and lead oxides) was Helm bank. Helm bank was reported to be ". . . three miles N.E. of the furnace . . ." (Rogers, 1858, v. 1, p. 268). Within the probable error limits for distances given by the First Pennsylvania Geologic Survey, there are three areas appropriately situated relative to Mary Ann Furnace. The first was known as the G. H. Cleaver bank by the time of the Second Survey (d'Invilliers, 1886), and is now beneath a housing development. The second is a water-filled pit on the south side of a secondary road, 0.9 mile (1.5 km) east of Chestnut Crossroads. This pit, which is 2.8 miles (4.45 km) northeast of Mary Ann Furnace, is the one sampled. The third possible location for Helm bank is an unexamined depression in an orchard 3.0 miles (4.8 km) northeast of Mary Ann Furnace. Helm bank was apparently abandoned prior to the time of d'Invilliers' report and maps (1886).

Mary Ann Furnace itself is on the northwest slope of South Mountain in Reservoir Hollow at an elevation of about 1030 feet (314 m), on the east side of a road 0.25 mile (0.4 km) north of a reservoir for Chambersburg and 1.65 mile south-southeast of Cleversburg.

Old Clippinger and Helm banks and Mary Ann Furnace are in Southampton Township, Cumberland County.

B.	LATITUDE N	LONGITUDE W
Old Clippinger (J. H. Cressler) bank	40° 01′ 54″	77° 29′ 25″
Helm bank (?)	40° 02′ 57″	77° 26′ 10″
Mary Ann Furnace	40° 00′ 50″	77° 27′ 40″

C. TOPOGRAPHIC MAP: Walnut Bottom $7\frac{1}{2}$-minute quadrangle.

3. *Host Rock:* The map of Gray and Shepps (1960) indicates that the Old Clippinger mine is probably underlain by interbedded limestone and dolomite of the lower part of the Elbrook Formation of Cambrian age. The prospect assumed to be the Helm bank in this report has been mapped as being underlain by the top of the Tomstown dolomite.

4. *Estimated Total Amounts of Ore Metals:*

A.	Old Clippinger (J. H. Cressler)	Helm(?)
<1 g:		
1-1000 g:		
1-1000 kg:	Zn, Pb	
>1000 kg:	Fe	Fe

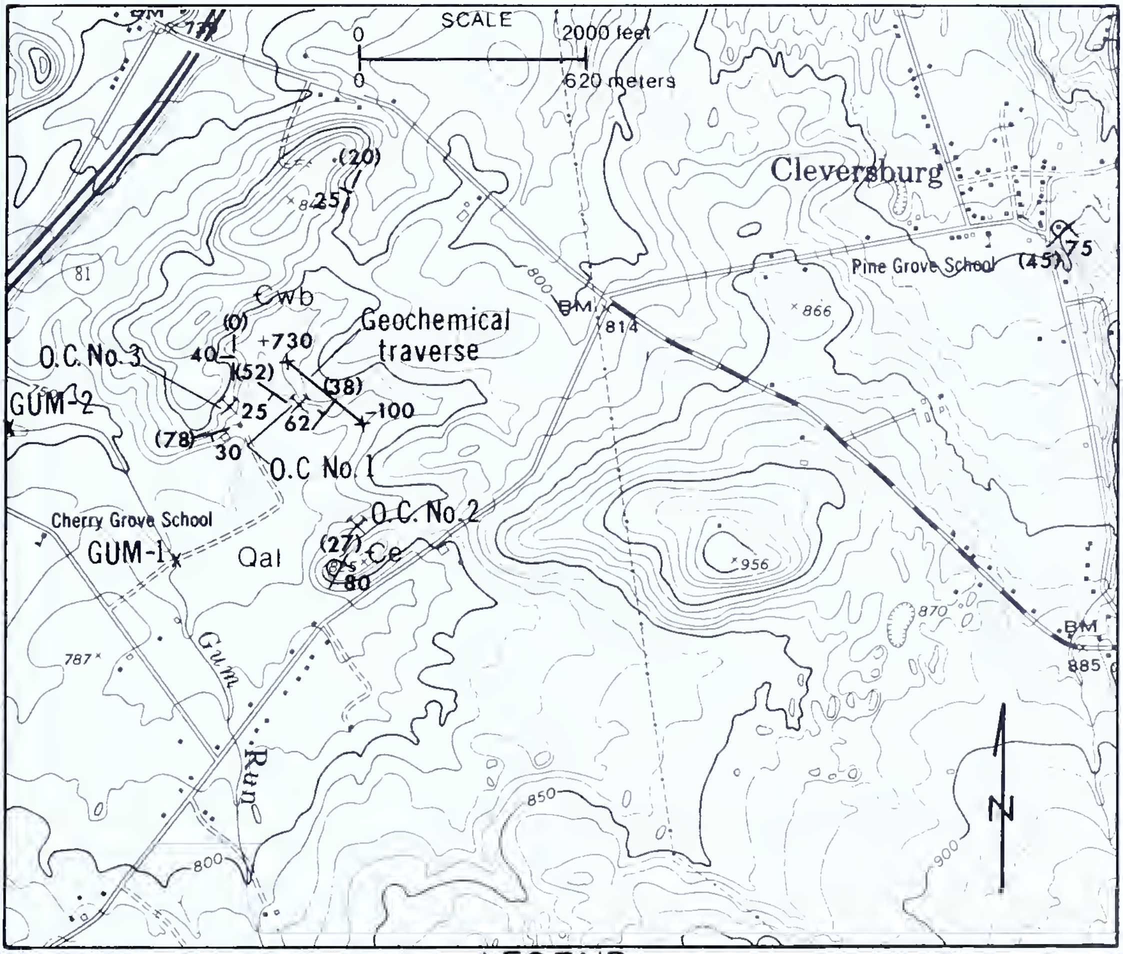
B. ASSAYS — limonite iron ores (in ppm unless noted):

	Co	Ni	Cu	Zn%	As	Ag	Pb	Sample Size
Old Clippinger (J. H. Cressler) No. 1	130	97	58	.27	18	.22	465	75 one-inch chips
Old Clippinger (J. H. Cressler) No. 2	—	—	94	.28	—	—	450	100 one-inch chips
Old Clippinger (J. H. Cressler) No. 3	110	80	24	.12	.5	.04	180	50 one-inch chips
Helm(?)	130	73	65	.06	28	.14	52	90 one-inch chips

Limonite samples Old Clippinger No. 1 and No. 2 are anomalously high in zinc, and especially lead, when compared to most low-manganese limonites in southeastern Pennsylvania. See Figure 12 for sample locations. Sample O. C. No. 2 may represent man-transported ore originally mined in the vicinity of O. C. No. 1, and a complete analysis was therefore not obtained.

5. *Minerals Observed and Relative Amounts:*

A. ECONOMIC	Old Clippinger (J. H. Cressler)	Helm(?)
Major:		
Minor:		
Trace:		
B. GANGUE		
Major:	"Limonite"	"Limonite"
Minor:	Goethite* (tan, waxy "clay")	
Trace:		



LEGEND

30↘(28) Strike and dip of bedding

25↘(20) Approx. strike and dip of bedding

(26) 80 Strike and dip of overturned bedding

+730 —— -100 Location of soil sample traverse

× GUM-2 Location of stream sediment sample

⚒ O.C. No.3 Location of limonite sample and possible shaft site

Qal	QUARTERNARY ALLUVIUM
Ꞓe	CAMBRIAN ELBROOK
Ꞓwb	CAMBRIAN WAYNESBORO?

Figure 12. Geology and sample locations at Old Clippinger (J. H. Cressler) bank area, Cumberland Co.

6. *Paragenesis:* Unknown, all minerals described are believed to be supergene. The Old Clippinger limonite has a trace-element content which suggests that it may be a gossan after sulfide mineralization.

7. *Geologic Description:* Old Clippinger bank is located just off the northwest flank of the South Mountain anticlinorium. This regionally plunging (northeast in Cumberland County) anticlinorium has a core of Precambrian Catoctin metavolcanics over which are draped multiply-deformed Cambrian-age sedimentary rocks (Root, 1970). Recent aeromagnetic data indicate a possible continuation of the South Mountain anticline beneath Carlisle, plunging beneath the Perry County Warm Spring (Peale, 1886) toward Lewistown.

Mary Ann Furnace was reported by Rogers (1840, p. 214) as having an incrustation of "cadmia" on the inner stack walls composed of 92.48% zinc oxide and 6.48% lead. Rogers (1858, v. 1, p. 268) notes that ore for Mary Ann Furnace was supplied by Helm bank and Clippinger banks.

> The Helm Bank overlies that part of the limestone which is much interstratified with slate, being near its margin. The ore dips steeply to the N.E., but varies much in quantity in different parts of the excavation. The Clippinger Bank yields an ore of the very best description, much of it being stalactitic, or of the kind called pipe ore. . . . The Clippenger ore occurs in regular nests in the interstices of the limestone rock, surrounded by a very tenacious reddish clay. The quantity fluctuates much in different spots, and the water incommodes more or less the deeper diggings. . . . The flux used in Mary Ann Furnace is a limestone procured in the vicinity of the Clippinger Bank (Rogers, 1858).

As noted by A. V. Heyl, who brought the incrustation analysis to the attention of the author, the source of the zinc and lead in the furnace walls could have been the limestone flux. However, the limonite analyses from the Clippinger bank strongly suggest that it is the source of the zinc. Such zinc oxide-clogged iron furnaces have led to discovery of zinc occurrences elsewhere along the Appalachians.

Helm bank lies along a major northwest-trending lineament across southeast and central Pennsylvania (Smith and others, 1971). Clippinger bank is somewhat to the west of the lineament's location as seen on Earth Resource Technology Satellite (ERTS) imagery, but does lie on a major east-west vertical fault first observed by S. I. Root (personal commun., 1974) on high-altitude color photography and later field checked. Recent field mapping by Root revealed that the east-west fault passes directly through the Ahl bank, 1.6 miles (2.6 km) southwest of Shippensburg. Limonite from the Ahl bank was found to be pseudomorphous after pyrite.

The Old Clippinger mine is located in the wooded area over a possible syncline in the Cambrian Elbrook Formation as shown in Figure 12. The syncline probably plunges to the southwest, and the axial plane probably dips steeply southeast (Root, personal commun., 1975). Outcrop is poor, but some folds and southeast-dipping faults seem necessary to explain the anomalous northwest strikes.

Eight B-zone soil samples were collected at approximately 100-foot (30 meter) intervals [except for 0 + 600 feet (185 m) and 0 + 700 feet (210 m), which fell in a cultivated field and were not collected] on an 830-foot (255 m) traverse trending N50E (Figure 13). The traverse began in the tree row leaving the northeast corner of the wooded mine area (Figure 12). Station 0 was in the tree row 105 feet (32 m) north of the main woods. The following total zinc and lead contents were found:

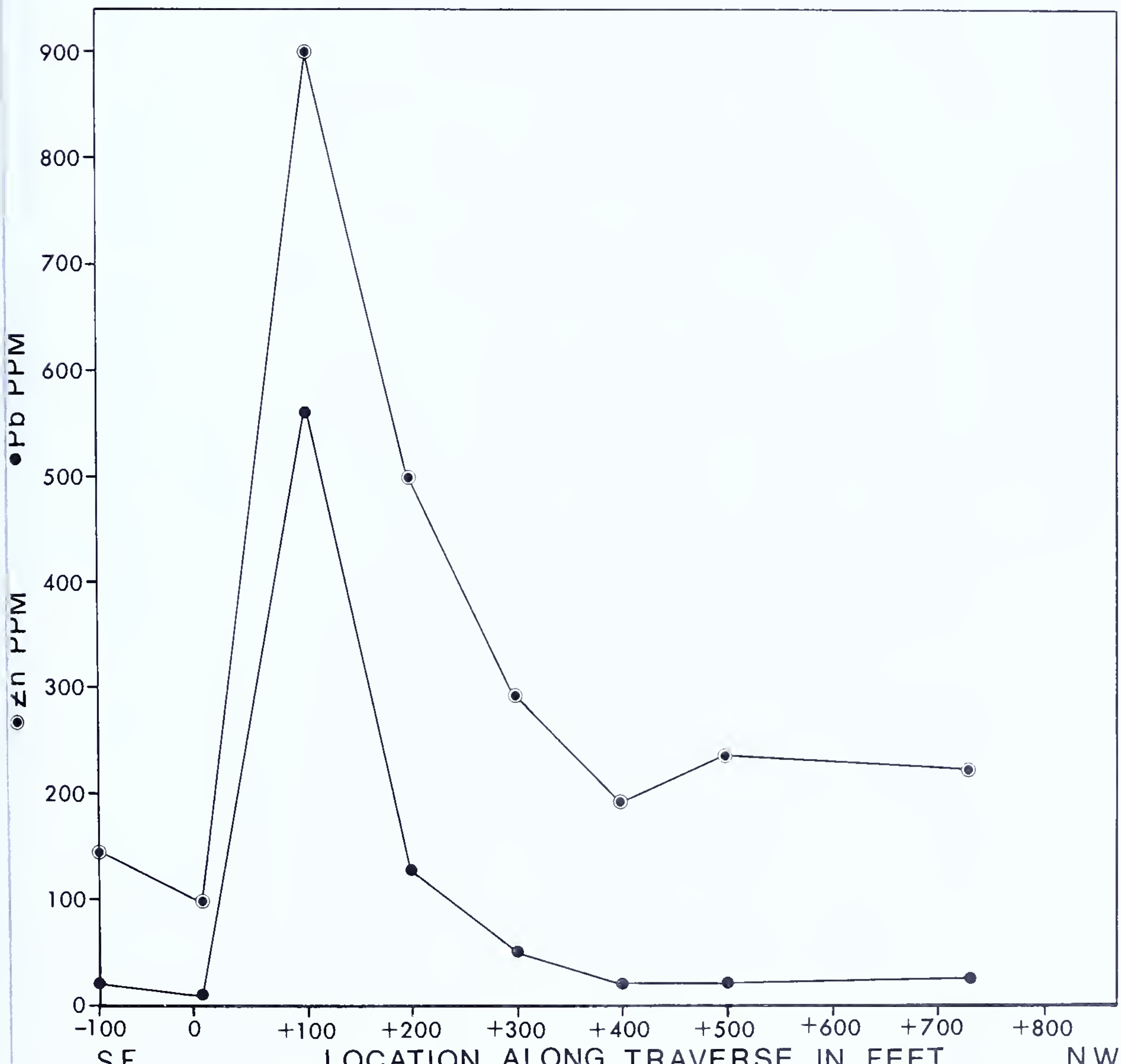


Figure 13. Geochemical analyses of B-zone soil samples to the northeast of Old Clippinger bank, Cumberland Co.

Location	Zn ppm	Pb ppm	Comments
−100	145	22	uphill, to S.E. of gully; orange-brown clay
0	91	8	silty loam, little clay
+100	900	565	orange-brown clay
+200	500	128	do.
+300	290	50	do.
+400	190	22	do.
+500	235	21	poorly developed B zone, shaly
+730	222	25	orange-brown clay

Samples +100 through +300 are definitely anomalous for both zinc and lead.

Stream sediment samples were collected from Gum Run as shown on Figure 13. These were found to contain background amounts of Zn, Pb, and Cu: Gum 1 - 120, 33, 12 ppm and Gum 2 - 37, 9, and 7 ppm Zn, Pb, and Cu, respectively. Although the values are low, drainage from mineralization may be subsurface, may be trapped by observed swamp muck, or only trace of mineralization may reach the present surface. Further soil sampling seems warranted. Both the Old Clippinger and Helm(?) banks are at unusual stratigraphic horizons for residual limonite. Other unexamined limonite mines in this area such as Bridges, Chestnut, Coffee, and Muslin, also appear to be at unusual stratigraphic levels and should be sampled.

13. PEQUEA AND BURNT MILLS SILVER MINES AREA, LANCASTER COUNTY

(Abandoned Lead-Silver Mine With Small Production)

1. *Name:* The Pequea Silver Mine was formerly owned by Fred Erb of Rawlinsville, but is reported to have been sold within the last few years to J. M. Brenner Company and renamed "Silver Ford." The Burnt Mills Silver Mine is owned by J. Polly. A mineralized occurrence in the roadcut along Pennsylvania Route 324 is probably on the right-of-way, and other mineralization may occur on the Nevin Good and other farms.

2. *Location:* To avoid confusion, the three main workings will be designated as A, B, and C following the convention of Foose (1947). Occurrences named for the first time in this report include Vertical Shaft, Route 324 Roadcut, and Fallen Tulip Poplar Adit (Figure 14). See section 7 for a description of the workings.

A. The entrance to Mine A or the Burnt Mills Silver Mine is located 300 ± 50 feet (90 m) N35 ± 5W of the southwest end of the Pa. Route 324 bridge over Pequea Creek. Mine A consists of an adit and open cuts on the northeast side of a knoll about 475 feet (150 m) S40W of the intersection of Silver Mine Road and Pa. Route 324 (see Figures 14 & 15).

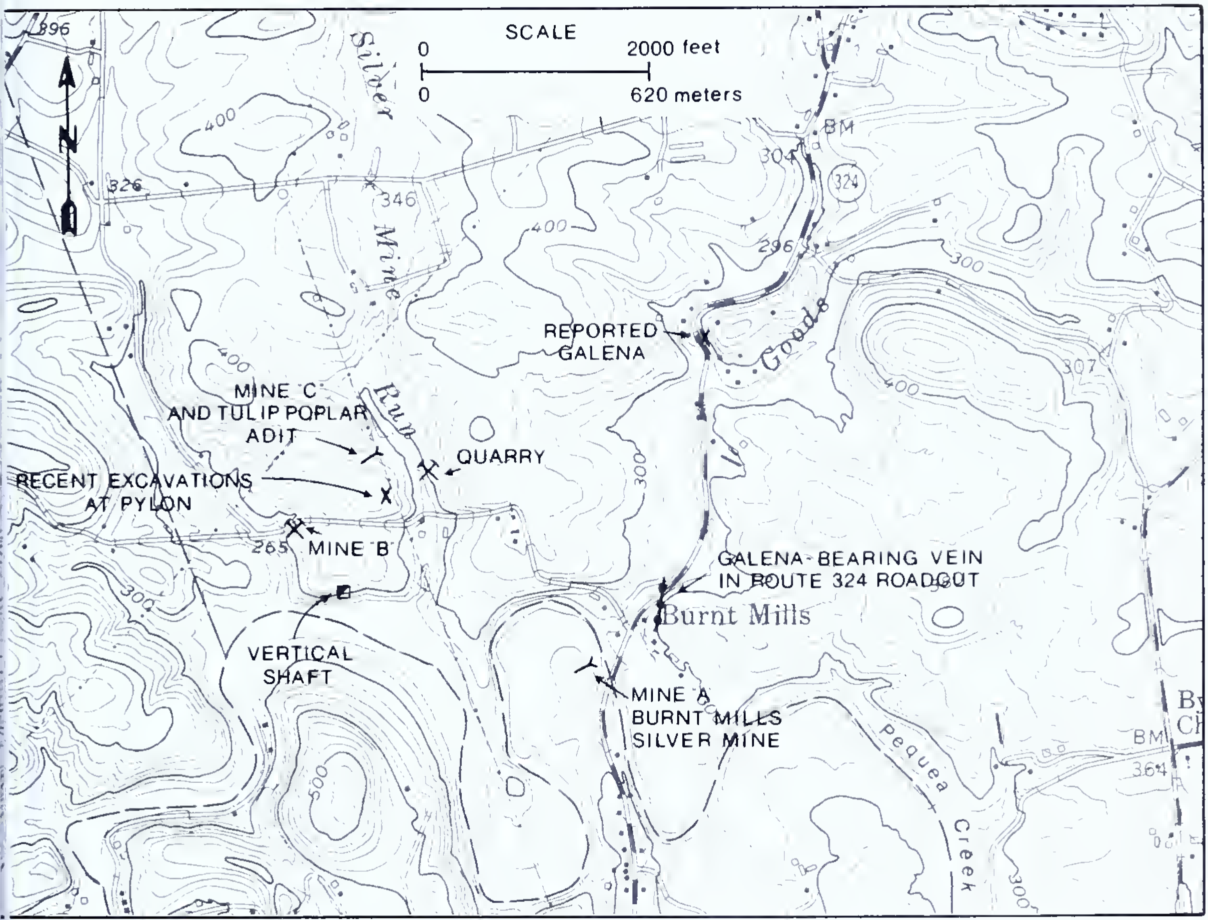


Figure 14. Prospect and mine locations in the Pequea-Burnt Mills silver mine area, Lancaster Co.

The entrance to Mine B is located 30 feet (9 m) south from the center of Silver Mine Road at a point 450 ± 25 feet (140 m) east of a bridge over an unnamed tributary of Pequea Creek near the intersection of Goods Road and Silver Mine Road. This area is 1.1 miles (1.75 km) east of the 5-point intersection in northeast Conestoga. This mine was located by means of directions from Dr. John W. Price, L.F.D., of Franklin and Marshall College (personal commun., 1972).

The entrance to Mine C (Figure 16), the main Pequea Silver Mine, is located along a private road past the kiln (Figure 17) which is along the west side of Silver Mine Run at a point about 600 feet (180 m) north-northwest of the bridge for Silver Mine Road over Silver Mine Run. Plate 4 of Freedman (1972) by D. U. Wise indicates that the entrance is 565 feet (170 m) N38W of this bridge. (The locations for C, as well as A, given on Plate 3 of Freedman (1972) are only approximate.) The Mine C area is 1.3 miles (2.1 km) due east of the same 5-point intersection. The main Pequea

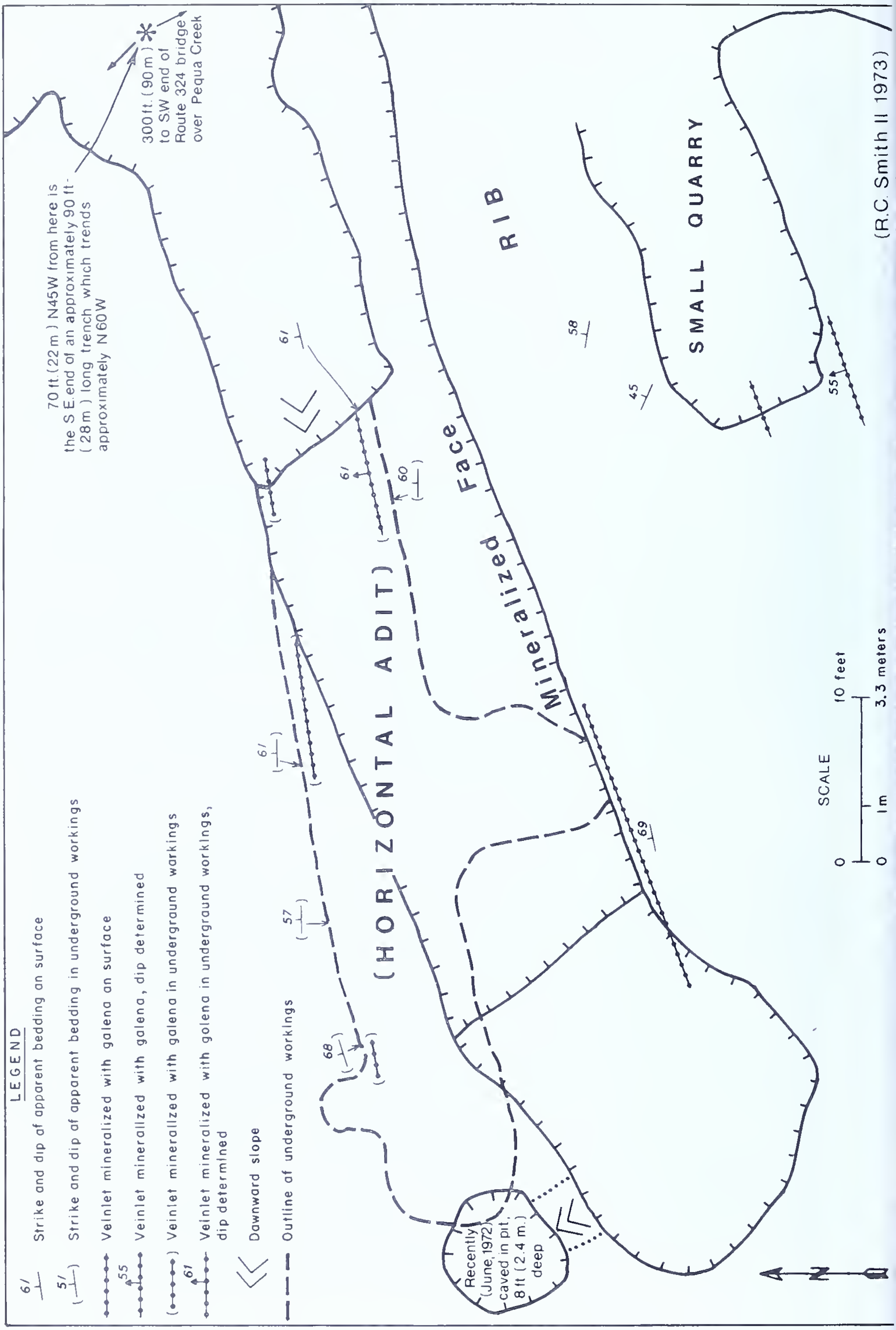

LEGEND
Strike and dip of apparent bedding on surface
Strike and dip of apparent bedding in underground workings
Veinlet mineralized with galena on surface
Veinlet mineralized with galena, dip determined
Veinlet mineralized with galena in underground workings
Veinlet mineralized with galena in underground workings, dip determined
Downward slope
Outline of underground workings
70 ft. (22 m) N45W from here is the S.E. end of an approximately 90 ft (28 m) long trench which trends approximately N60W
300 ft. (90 m) to SW end of Route 324 bridge over Pequa Creek
RIB
SMALL QUARRY
Mineralized Face
(HORIZONTAL ADIT)
Recently (June, 1972) caved in pit, 8 ft (2.4 m.) deep
SCALE
0 10 feet
0 1m 3.3 meters
(R.C. Smith II 1973)
N

Figure 16. Entrance to Pequea mine C prior to restoration. The rock at the entrance is a phyllitic limestone of the Conestoga facies.

Silver Mine is 5 miles (8 km) northeast of the town of Pequea. Freedman (1972, p. 34) mentions additional open cuts in the Mine C area.

The Vertical Shaft (Figure 14) is on the bluff overlooking Pequea Creek at an elevation of about 300 feet (90 m) [about 5 feet (1.5 m) below the level of the south edge of the field] at a point which is 0.5 mile (0.8 km) west-northwest of the intersection of Silver Mine Road with Route 324. This area is 500 feet (150 m) northwest of the intersection of Silver Mine Run with Pequea Creek, 700 feet (210 m) south of Silver Mine Road, and 950 feet (290 m) southeast of the junction of Good and Silver Mine Roads. An anonymous article in the Journal of Silver and Lead Mining Operations (1853a) states that an adit level was being commenced about 100 feet downhill from the Vertical Shaft. No trace of the adit was observed during the present study.

The Route 324 roadcut, first mentioned in Foose (1947), is on the southeast side of the road at a point 400 feet (120 m) N52E of the intersection of Pa. Route 324 with Silver Mine Road. As noted by Freedman, this is "700 feet (215 m) north-northeast of the center of the Pequea Creek bridge. . . ." Freedman (1972) also reported galena ". . . on the hill east of the sharp bend in the road north of Burnt Mills." Freedman (personal commun., October 9, 1972) located this *reported galena* 0.5 mile (0.85 km) north-northeast of the intersection of Silver Mine Road and Pa. Route 324. No galena was observed by the author at this latter location, and because he cannot add to Freedman's note, it will not be discussed further.

The Fallen Tulip Poplar Adit (Figure 14), part of the Mine C complex, is about 170 feet (50 m) southwest of the entrance to Mine C (D. Wise's Plate 4 in Freedman, 1972).

Freedman (1972) mentions that "another shaft was dug on the crest of the hill west of the mine area at the present site of a pylon for a powerline." The author found traces of galena in quartz float at this pylon, located about 250 feet (75 m) northwest of Silver Mine Road bridge over Silver Mine Run. The power pylon location has recently (late 1976) been excavated and yielded minor galena and rutile in quartz. It will not, however, be discussed further.

Six of the areas where the author has found galena are in Pequea Township, whereas the seventh, Mine A, is in Martic Township. All seven occurrences are in Lancaster County.

James D. Stauffer of Lititz has found sphalerite and galena traces along the east contact zone of a subvertical York Haven-type diabase dike at Rockhill along the Conestoga Creek. The author was only able to find pyrite in the contact-metamorphosed Conestoga phyllite. The location is a small quarry 165 feet (50 m) northeast of the dam on Conestoga Creek, Conestoga Township. This occurrence is 2.9 miles (4.6 km) northwest of Mine C, probably not directly related, and will not be discussed further.

Chapman (1950) described sphalerite in the contact zone of the same York Haven-type diabase dike at Safe Harbor. This location is approximately 4 miles (7 km) west-southwest of the Pequea Silver Mines area. The sphalerite here occurred as black, modified tetrahedrons up to 12 mm in diameter in talc and calcite veins in shattered, contact-metamorphosed Vintage dolomite about 50 feet (15 m) from the east contact of the dike. Recently the author and John H. Way have collected dark sphalerite in Vintage dolomite and galena in quartz veins from the same host in the Safe Harbor quarry (Smith, 1975). Adits similar to those at Pequea, but barren, occur in the Safe Harbor area. One barren 20-foot (6 m) trench and 20-foot (6 m) adit is located 420 feet (130 m) upstream from the east side of the Safe Harbor quarry and another "silver mine" is reported at Sickman's Mill (Karl Brubaker, personal commun., 1975).

B.	LATITUDE N	LONGITUDE W
Mine A	39° 56′ 27″	76° 18′ 29″
Mine B	39° 56′ 38″	76° 19′ 03″
Mine C	39° 56′ 44″	76° 18′ 51″
Vertical Shaft	39° 56′ 32″	76° 18′ 57″
Route 324 Roadcut	39° 56′ 32″	76° 18′ 20″
Fallen Tulip Poplar Adit (part of Mine C complex)	39° 56′ 43″	76° 18′ 51″

C. TOPOGRAPHIC MAP: Conestoga 7½-minute quadrangle.

3. *Host Rock:* Freedman (1972) states that the host rock for the Pequea deposits is dolomite in the Vintage Formation of Cambrian age, which in the mine vicinity is a "massive mottled light-gray to blue-gray finely crystalline" dolomite. Much of the mineralization occurs at the contact of the dolomite with a black, carbonaceous, calcareous, pyritic phyllite (see Figure 17) which has been interpreted variously as part of the Conestoga Formation of Ordovician age (Wise, 1960) or more likely, interfingered black-shale beds (Rodgers, 1968). Freedman (1972, p. C36) gives an excellent summary of the controversy.

4. *Estimated Total Amounts of Ore Metals:* (all occurrences together)

A. <1 g:

1-1000 g: Zn, Cu, R.E.O.

1-1000 kg: Ag, Ti, Bi(?)
>1000 kg: Pb

The above estimates are based on the author's estimate that about 2×10^3 tons of rock have been mined underground. An order of magnitude estimate of galena produced is 10 tons yielding an ore grade of 0.5% Pb produced by selective mining. At present prices (Feb. 1974), 10 tons of galena would yield $9,200 in Ag, assuming that the galena averages 275 oz/ton Ag, which seems generous, and $3,200 in Pb. The value of each ton of rock mined would then be $6, a low value for selective mining. A small production from pre-Revolution small pits is also likely.

Figure 17. A lime kiln on the road to Pequea mine C suggests that at least some of the quarrying was for limestone. The rutile-galena-mica-bearing rock outcrop occurs just uphill (behind) the kiln.

B. ASSAYS: The editor of the *Lancaster Whig* reported that Dr. Fahnestock assayed the galena at upwards of $500 per ton at 1853 silver prices (Jour. Silver and Lead Mining Operations, 1853). The Lancaster Lead Company Prospectus of 1863 reports that the galena contains 10 to 16 oz Ag per ton, ". . . the coarser grained galena giving the most, and the finer grained the least." In that same prospectus, however, Professor Charles A. Joy of the Columbia College Chemical Laboratory reports only 7 oz Ag/ton from both the wide and narrow veins. Torrey (1863) found 179½ oz. Ag/ton and Genth (1875) determined 250-300 oz Ag/ton. Eckman (1927) reports that Professor H. H. Beck of Franklin and Marshall College found that the galena contained 250 oz of silver and a trace of gold. A. V. Heyl (personal commun., 1968) reported that pure galena from Pequea Mine C[1] contained 2% (600 oz/ton) Ag, 7% Bi, 5 ppm Ba, 150 ppm Cd, 100 ppm Cu, 300 ppm Sb, and 7 ppm V, all by semi-quantitative emission spectrographic procedures. Using a fire assay-atomic absorption procedure, Fred Simon found <0.05 ppm Au and 20,000 ppm (2%) Ag in the same sample (Heyl, personal commun., 1976). Freedman (1972) reports a modern analysis also by the U. S. Geological Survey of 168 oz Ag/ton of galena which he collected from Mine C. Most of these analyses are probably of samples from Mine C. Until additional data are obtained, 275 oz Ag/ton galena (the average of Genth's assays) will be assumed as a possible, typical value.

1. Collected by Robert E. Zartman in the early 1960's.

5. *Minerals Observed and Relative Amounts:*

A. ECONOMIC

Major:	Galena[2]
Minor:	Anglesite
Trace:	Cerussite, sphalerite (golden-brown), chalcopyrite, aurichalcite(?), malachite,[3] pyromorphite*

B. GANGUE

Major:	Quartz[4] (milky and clear), pyrite (in calcareous, carbonaceous phyllite)
Minor:	Adularia, muscovite, rutile,[5] pyrite (with galena in vein quartz), calcite
Trace:	Monazite (clear golden prisms in galena from Mine A)

6. *Paragenesis:* Syngenetic pyrite in black phyllite; tectonic deformation; quartz; and galena with some overlap between the last two.

7. *Geologic Description:* Many have dealt with the geology and history of the Pequea area and for the past several decades it has been the subject of detailed study by the staff of Franklin and Marshall College. This and other geologic data presented in less-available literature will be quoted extensively, whereas readily available literature will be cited, but will only be briefly discussed.

The first published reference to Pequea Silver Mine was the location of a "Lead Mine" on the map of Pennsylvania by W. Scull (1770). The earliest geologic reference, Silver Mines in Pequea Valley, Pennsylvania (1853a), reports that the quartz veins trend ". . . northeast by southwest, in a direction contrariety to the regular stratification" (p. 647).

The Lancaster Lead Company prospectus of 1863 (Mallory, 1863) states that "The general course of the veins is east and west. . . ." The prospectus reports two 6-inch (15 cm) veins which are parallel, 7 feet (2.2 m) apart, and have a dip of 35°. Three other veins are described on the top drift where it is 10 feet (3 m) wide and 22 feet (6.7 m) below the surface. There are ". . . two north veins, 2 feet apart, and the foot-wall vein, which is 10 feet south from the north wall of the north vein." As described in this prospectus, the Lancaster Lead Company sank six shafts, all shallow, " . . .

2. Some of the galena from Mine C has an anomalous octahedral cleavage or parting in addition to the usual cubic cleavage (see Figure 22). X-ray diffractometer scans, however, show no difference.
3. Verified by Mary E. Mrose, U. S. Geological Survey.
4. Many quartz crystals are flattened into a tabular habit by differential growth of the prism faces.
5. Verified from Tulip Poplar Adit area and Mine C by electron diffraction and emission spectroscopy by N. H. Suhr, Mineral Constitution Laboratory, The Pennsylvania State University, 1967.

on a direct course from the first, 10 to 15 feet apart." The prospectus optimistically states that ". . . it is a well known fact that veins such as those we are now working are seldom ever known to give out" and that silver-bearing lead veins ". . . penetrate the rocks to such depths that they may be regarded as altogether inexhaustible."

Foose (1947) gives more scientific descriptions. He notes that the mine area is in the middle of a three-mile wide, east-west zone in which the Antietam, Vintage, and Conestoga Formations are repeated several times by folding, normal faults, and reverse faults. He states that the zone is bounded on the north by Conestoga limestone and on the south by schists of the Martic thrust. Foose notes that galena is present on the bottom of those veins which dip less than 60° and that the quartz is clearer near galena.

Foose (1947) reports that:

> Mine A is located on the north flank of an east-west striking anticline about 75 to 100 feet below the crest. At this mine [Figure 16 of this report] thin quartz veins, ranging from one-eighth to one and a half inches thick, follow the bedding planes of massive Vintage dolomite, dipping 60 degrees north, and also intrudes the beds in a position parallel to the bedding. Although the veins were not observed to carry any ore, it is obvious the mine was developed along their trend. A prominent joint set, striking slightly east of south is also mineralized, but the quartz veins are much thinner. A short crosscut has been driven along this joint set.

The present author found a relatively large amount of galena in the Mine A area. The 44-foot- (13 m) long horizontal adit (Figure 18) appears to have been developed along two $^1/_4$-inch wide, discontinuous, bed-parallel galena veins. The northern vein is mineralized as far west as the small crosscut to the south, but is then barren until a point just east of the small crosscut to the north is reached. Here, a bat frequently sits on the best galena. Thin approximately $^1/_8$-inch- (3 mm) wide veins of quartz and galena break off from the northern vein at high angles. Scattered patches of adularia and quartz, mostly about $^3/_8$-inch (1 cm) thick, occur

Figure 18. Inside the Burnt Mills adit, Pequea mines area, Lancaster County after the June 1972 Agnes flood. The hammer is against a galena-bearing joint or cleavage surface.

at several places along the northern vein. The south vein loses its identity about 5 feet (1.5 m) from the adit entrance. Neither the north nor the south vein is slickensided and both parallel phyllitic layers which strike just north of east and dip about 60° to the north. The veins are apparently developed along bedding. Where exposed in the vertical face above the adit entrance, galena occurs in discontinuous masses up to ½-inch (1.2 cm) thick. Here the veinlets are surrounded by approximately 2 inches (5 cm) of white, saccharoidal limestone with a fair cleavage. The galena occurs in nuggets along a chocolate-brown, sandy stripe through this limestone. This galena is intimately associated with adularia[6] and traces of rutile. The mineralized face forming the south-southeast face of the trench above the adit is mineralized with galena both along the surface and in small gash veins which penetrate an inch or so off from it. Galena up to 1-inch (2.5 cm) thick in plates up to 10 inches (25 cm) across occurs for 20 feet (6 m) along this surface (see Figure 19). Here, the galena is in dolomite (without significant adularia), has only a cubic cleavage and is associated with traces of limonite and pyrite. The vein in the small quarry, south of the adit entrance, is 2-3 inches (6 cm) wide and contains 10-50% galena. This vein strikes approximately N70E and dips approximately 55N. A few minute monazite crystals occur within the galena. The small dumps north of the adit entrance yield galena in milky quartz and traces of chalcopyrite.

Figure 19. Galena on a joint surface in the open trench above Burnt Mills adit. The moss grows vigorously on the carbonate rock, but not on the galena.

The Mine A area contains the best mineralization observed in the Pequea area, but no so-called Conestoga black limestone phyllite was observed. The role of the Conestoga-Vintage contact has therefore probably been overemphasized.

Foose (1947) describes Mine B (see Figure 20 of this report, from Foose) as follows:

> Mine B is located on or near the crest of a prominent fold in the massive beds of the Vintage dolomite. Quartz veins, ranging in

6. Possibly suitable for K-Ar determinations.

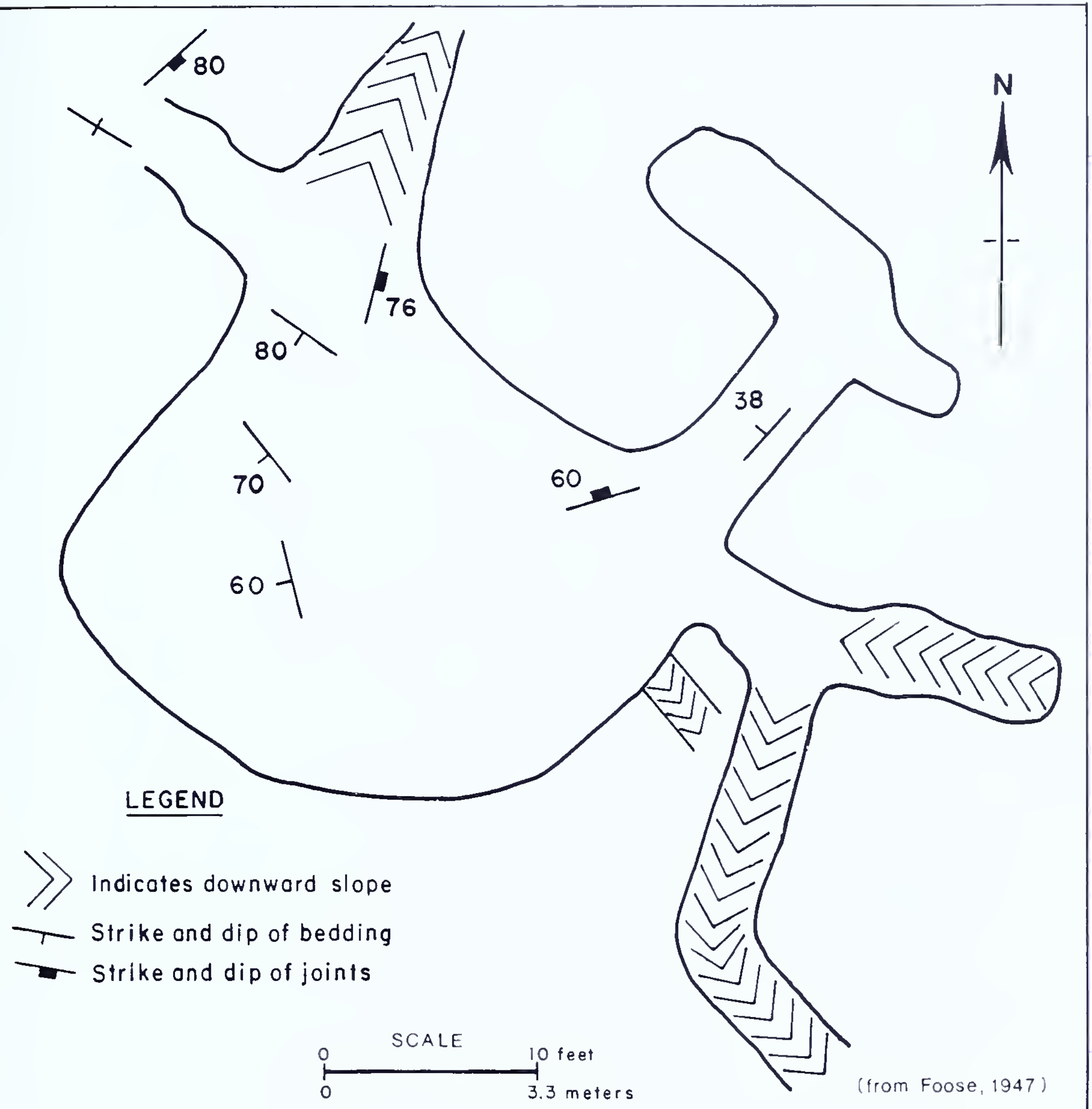


Figure 20. Workings and geology of Pequea mine B.

thickness from one-eighth inch to nearly one foot are situated along the bedding planes and two prominent joint sets. It was impossible to follow this mine to its full extent because the slopes are filled with washed-in dirt. Again it is clear that mining was guided by the quartz veins, even though no ore was obvious at any place in the mine.

Dr. John W. Price of Franklin and Marshall College (personal commun., 1972) reports of a visit a few decades ago that "The mine was close to the

surface and at one place we could see daylight through a hole to the surface that allowed a lot of mud to wash into the mine when it rained, . . ." Neither Price nor the present author were able to find any galena in the vicinity of Mine B. The author only found abundant quartz crystals loose in the soil about 200 feet (60 m) southwest of Mine B. The mine entrance is presently obscured by rubble and was not entered. The quartz crystal distribution, however, suggests an E-W vein, but this was also the maximum slope direction.

Foose (1947) describes Mine C as follows:

> It has been "driven" along both bedding planes and joint planes in either the Vintage dolomite or Conestoga limestone, and possibly both. . . . It is obvious, however, that the quartz veins, which have an average thickness of five or six inches, and which range in thickness from thin stringers to massive two-foot veins, are localized along pre-existing structures. The quartz also occurs in two other ways at this mine: (1) As veins in a brecciated zone, which may be bedding, and which dips 25 degrees northwest. The first slope in the mine is developed along this zone. (2) As gash veins, two to eight inches long and as much as one inch thick, usually close to a continuous vein along either bedding or joint planes.

Wise (1960) includes detailed geologic maps of the Mine C area and the mine proper which were utilized by Freedman (1972) as Plate 4 and Figure 8, respectively (Figure 21). Wise notes that:

> Most of the workings are located on the crests of minor folds or zones of tighter crumpling. (a) The folds show a very complex pattern of strikes and plunges but most have a general north or northeast strike. (b) Some of the axial planes are quite flat approximately 60 feet from the rear of the mine, in the upper workings of the "gopher hole" and as indicated by some low dipping cleavages near the mine entrance. (c) The folds near the mine entrance show plunges both toward the north and toward the south. (d) The entire pattern is one of disharmonious folding. . . . The control of the ore is largely the result of yield differences between the Conestoga phyllites, which flowed without separation, and the more brittle Vintage dolomite, in which open joints were created to produce ready access for the quartz bearing solutions.

The present author observed galena in the upper level of Mine C proper at only one place. This trace of galena in quartz (Figure 22) occurred in dolomite 2-6 inches (5-15 cm) from the phyllite. According to the map of Wise (1960) this location is 195 feet (60 m) from the adit entrance at a point where bedding strikes N77W and dips 35N. Walking into the mine, it is 255 feet (78 m) from the entrance and 65 feet (20 m) past the incline-gopher hole to the surface. The incline-gopher hole to the surface follows a dolomite-phyllite contact along which considerable solution has occurred (see Figures 23 and 24). Probably this would have developed into a cave

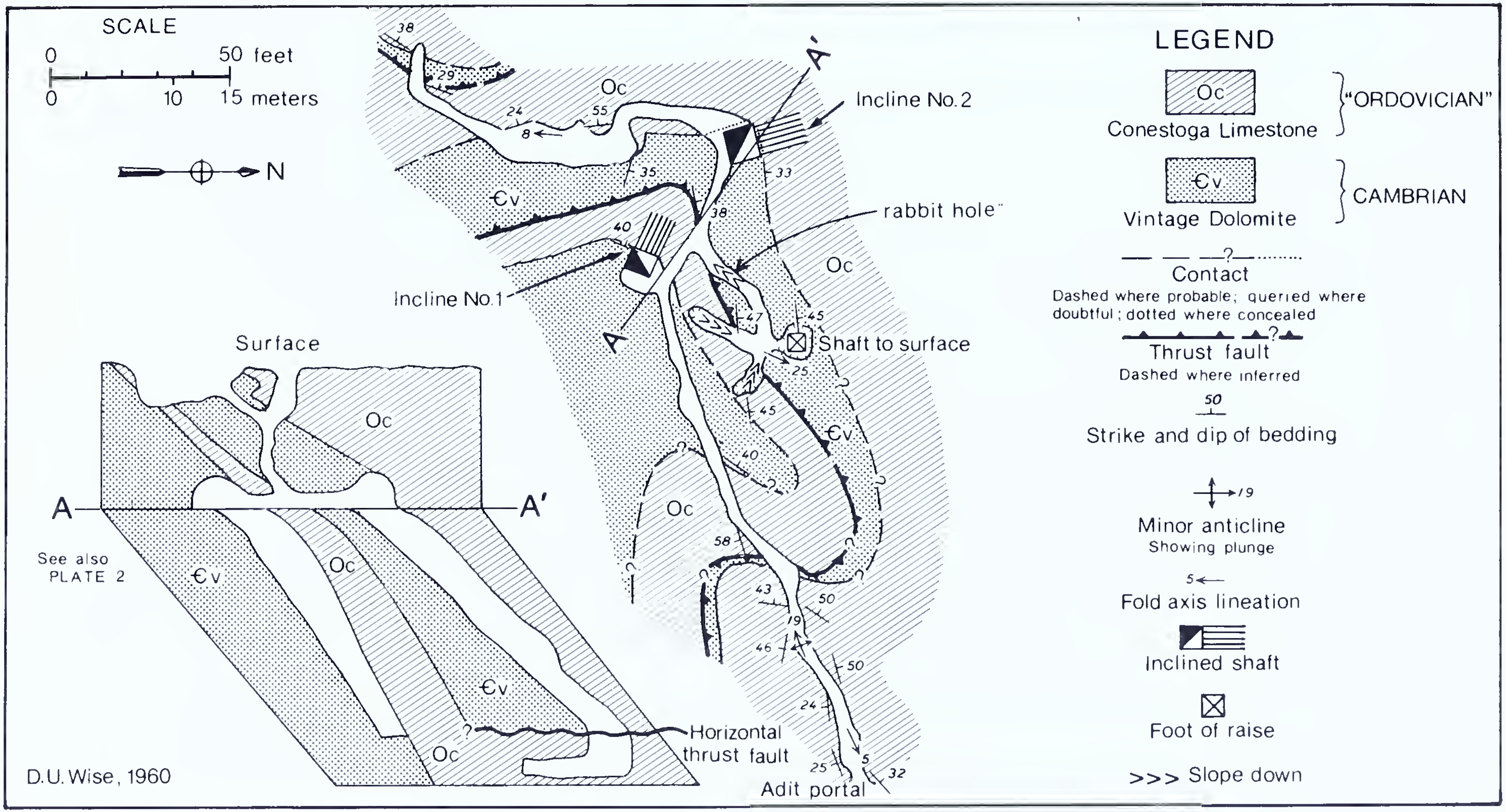


Figure 21. Workings and geology of Pequea mine C (modified from Freedman, 1972).

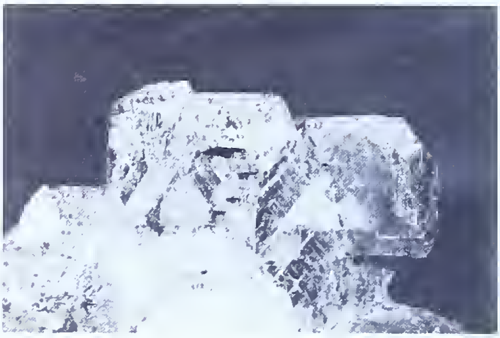


Figure 22. Specimen of galena with cubic and octahedral cleavages on quartz, Pequea mine C, Lancaster County. (Specimen collected by D. Schmerling; photo courtesy D. L. Oswald, Carnegie Museum, Pittsburgh.)

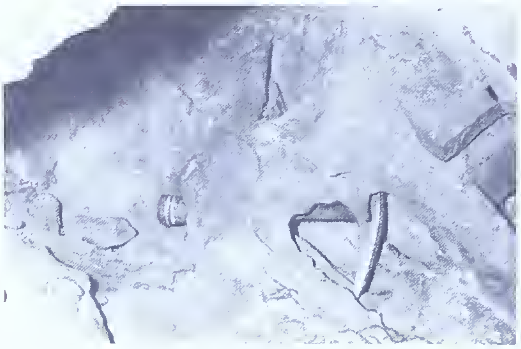


Figure 23. Solution-sculptured Vintage dolomite near contact with the Conestoga, "rabbit hole" (see Figure 21) from Pequea mine C to surface.

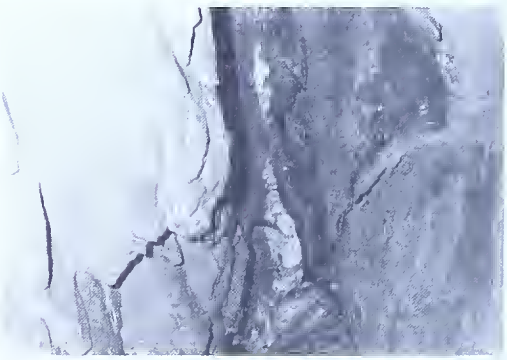


Figure 24. Quartz vein along solution-sculptured contact between Vintage dolomite (left) and Conestoga limy phyllite (right), (rabbit hole, Pequea mine C)

with time. In the Mine C horizontal adit itself there are many, small 1-to 2-foot- (30-60 cm) wide cave-like openings in the dolomite which are lined with quartz crystals up to 4 inches (10 cm). Pyrite is abundant in the phyllite exposed in the mine.

In July, 1976, the author was fortunate to be able to map and examine the recently pumped out inclines in Pequea Mine C. Incline No. 1 plunges northwest at about 38° and has an average height of 9 to 10 feet (2.8 to 3.0 m) and width of 7.5 feet (2.3 m) (see Figure 25). Bedding at the bottom of incline No. 1 is approximately N73E, 37NW. The roof of the incline is Conestoga phyllitic limestone and the development was in Vintage dolo-

mite. The Conestoga exposed in the roof is slickensided, but the slickensides appear to lack a predominant orientation. The Vintage contains irregular white dolomite ovids (carbonate clasts?) near the contact with the overlying phyllite (see Figure 26). Although gash veins are very abundant, substantial chipping failed to reveal galena ore.

Incline No. 2 plunges north at 60° (see Figure 27), becomes a nearly vertical shaft, and then continues beneath itself as a short drift. The short drift was driven entirely in Conestoga phyllite following the crest of a fold that trends S9E and plunges 28° to the south. This phyllite appears to have been very pyritic prior to leaching. A shallow-dipping thrust fault at the change in slope of the incline from 60° to 90° has displaced the Vintage "ore horizon." Unfortunately, no drifting was done along the brecciated Vintage above the thrust fault. The 60° plunging portion of the incline has phyllite roof with development in dolomite. Gangue veins are abundant, and a trace of galena was found about 28 feet (8.5 m) down the incline from the adit level. Incline No. 2 now has a modern wooden stairway, but wooden platform levels (for staggering ladders) and remains of ladders date from the 1860's (see Figure 28). Iron-strapped rails on the east side of the incline and step-like notches for support occur along the incline as indicated in Plate 2a.

Foose (1947) states that the 35-foot (11 m) Vertical Shaft overlooking Pequea Creek "has been blasted downward on a massive quartz vein that

Figure 25. Assistant descends incline No. 1, Pequea mine C, Lancaster County.

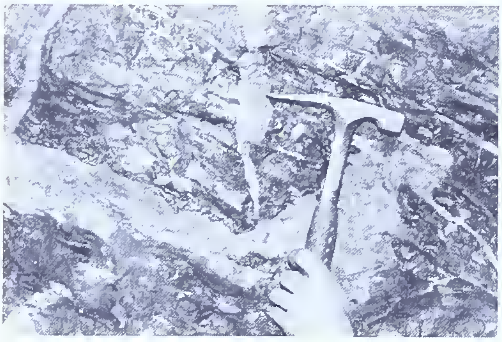


Figure 26. Peculiar breccia at the top of the Vintage dolomite in incline No. 1, Pequea mine C, Lancaster County.

Figure 27. View looking down incline No. 2, Pequea mine C, Lancaster County. Incline drops off to vertical beyond field of view.

Figure 28. Examining two levels of Civil War-vintage wooden platforms in incline No. 2, Pequea mine C, Lancaster County.

is apparently located along a joint that has suffered some movement. Associated with the massive quartz vein are smaller gash veins about six inches long and as much as three-quarters of an inch thick." The present author did not enter this shaft, but Foose's description is certainly accurate for the portion visible from the surface. About 1 in 25 quartz-bearing rocks found on the dump contained trace to minor amounts of galena. This quartz occurs in dolomite and does not appear to be related to a contact with phyllite.

Foose (1947) describes the Pa. Route 324 roadcut as follows. Mineralization occurs in "an anticline of the Vintage dolomite. . . . A prominent joint set cuts the rock with dips to the northwest and these joints are mineralized in a manner identical to the three mines. At this location the

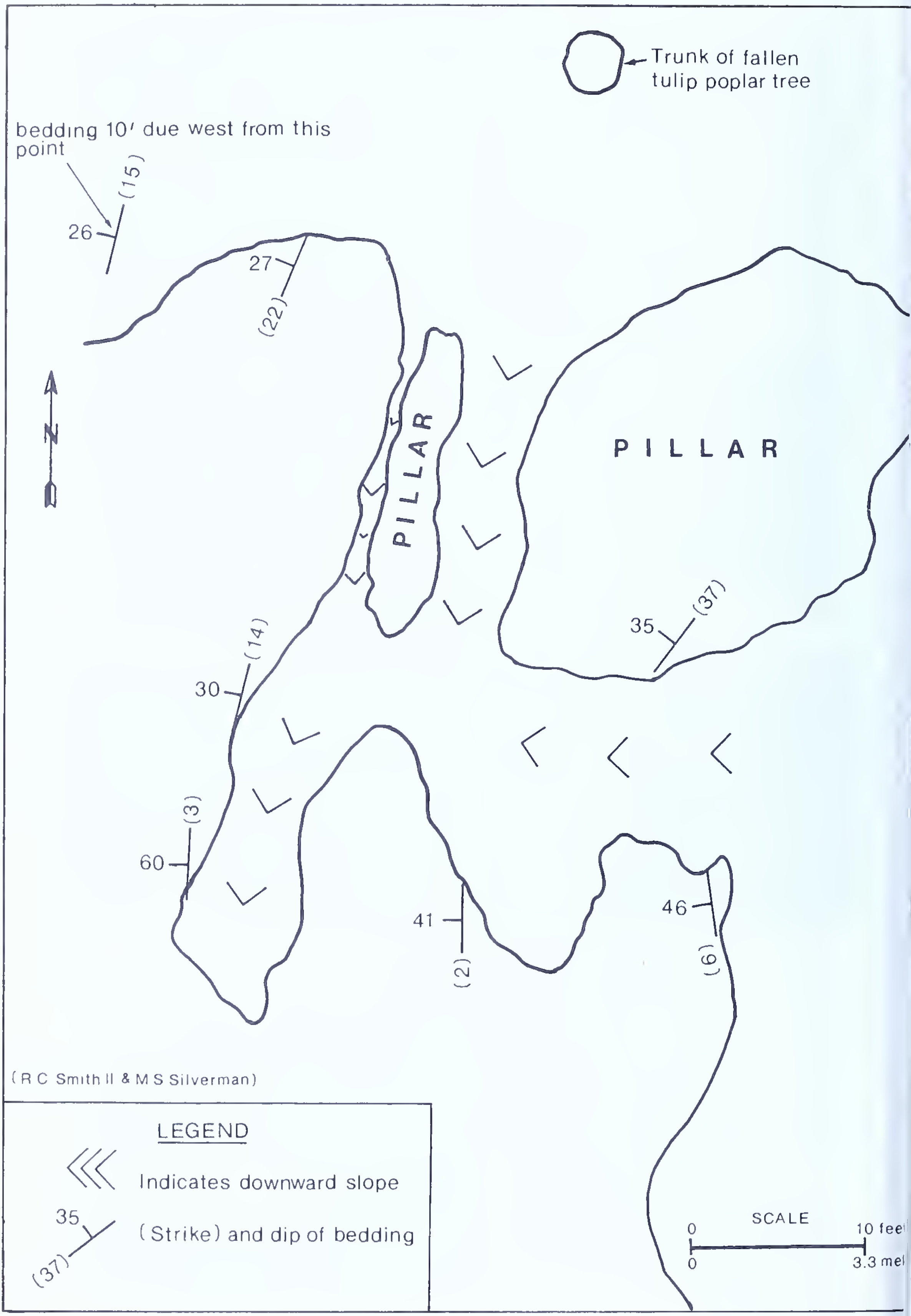
ore mineral may be readily collected, although it is certainly not abundant." As shown on Plate 3 of Freedman (1972), the northeast end of the outcrop is Conestoga phyllitic limestone and the southwest end, containing the mineralization, is Vintage dolomite. Here the Vintage is light gray with phyllitic layers. Bedding of the dolomite near the vein is N30E, 44SE. The galena (a few percent), pyrite, and adularia-bearing quartz vein is 3-5 inches (8-13 cm) thick, trends N7E, 41W, and is exposed for about 20 feet (6 m) across the outcrop.

The Fallen Tulip Poplar Adit is shown in Figures 29, 30 and 31. The adit is roughly "Y"-shaped and follows a phyllite-dolomite contact down the west limb of a plunging fold. The phyllite lies on top of the dolomite and according to Wise (1960), the fold plunges 10° to the WSW. Galena occurs with quartz in dolomite within a few inches of the phyllite contact in the roof of the north entrance to the adit.

Freedman (1972) presents the results of the geochemical trace analysis of 984 soil, rock, quartz, and stream sediment samples collected in the Pequea area. As noted by Freedman, most anomalies are single samples. "Plate 3 [of Freedman, 1972, p. 39-40] shows two conspicuous anomalies for lead. One area is about 1 mile west of Baumgartner along Route 325, and the other extends from Burnt Mills westward for about 1 mile." Interpretation is difficult because of the variety of geochemical materials

Figure 29. Geologist examines galena in quartz veins in northwest entrance to Fallen Tulip Poplar adit above Pequea mine C.

Figure 30. Quartz veins in brecciated dolomite at the incline from Fallen Tulip Poplar adit above Pequea mine C.



Trunk of fallen tulip poplar tree
bedding 10′ due west from this point
26
(15)
27
(22)
N
PILLAR
PILLAR
35
(37)
30
(14)
60
(3)
41
(2)
46
(6)
(R C Smith II & M S Silverman)
LEGEND
Indicates downward slope
35
(37)
(Strike) and dip of bedding
SCALE
0
10 feet
0
3.3 meters

included in the statistical treatment and the fact that sample sites may have been shifted to include anomalous materials (see discussion under Bamford Mine report). The anomaly at the intersection of Pa. Route 324 and Baumgardner Road may be in part a topographic effect.

The mineralization at Pequea has some similarities with alpine cleft mineralization[7] such as that at Kline's Quarry, Wrightsville, York County. At Kline's, minor galena with an octahedral cleavage in quartz, sphalerite, and chalcopyrite occur with adularia, chlorite, anatase, brookite, rutile, ilmenite, and monazite in the Antietam-Harpers Formation near its contact with the Vintage dolomite. In addition to mineralogy, the common factors between Pequea and Kline's quarry are the presence of the Antietam and Vintage Formations. Possibly, the source of the lead, titanium, silver, and potassium was hydrothermal solutions released by regional metamorphism of biotite, etc., in the Antietam Formation.

Eckman (1927), Price (1947), and Loose (1972) provide interesting accounts of the history of the mining which goes back to pre-Colonial times. The Pequea area continued to be examined by major mining companies as late as 1973, but their efforts seem to have centered on Mine C, and have completely ignored Mine A, perhaps because of Foose's "not observed to carry any ore" statement. For several years, a Mr. Hess of Lancaster held mineral leases of portions of the Nevin Good farm south of Goods Road (west of the Fred Erb property). Some drilling on the lead soil anomalies of Freedman (1972) was done for muscovite as well as lead and silver, but Hess is deceased and the results are not known. In 1973, F. Erb considered quarrying for dolomite with by-product silver at the Mine C area. Complex geology and transmission line rights-of-way would have made quarrying difficult. Most recently, J. M. Brenner has neatly developed the area for outdoor recreation. A detailed stream sediment survey using accurate and precise sampling and analytical techniques on a 0.5 km spacing of all drainages in the "thrust" area may be warranted.

The author gratefully acknowledges the assistance of Drs. Jacob Freedman and John Price of Franklin and Marshall College.

7. Low temperature redistribution of elements in rock-forming minerals into crystalline minerals lining vugs by low to moderate temperature hydrothermal solutions of unknown origin.

Figure 31. Geology and workings of Tulip Poplar adit, Pequea mine C complex, Lancaster Co.

14. YORK STONE AND SUPPLY COMPANY NEW QUARRY, YORK COUNTY

(Major Zinc Occurrence)

1. *Name:* The York Stone and Supply Company new quarry is reported to be owned by George Cramer, Sr.

2. *Location:* A. The new, active quarry is located on the northwest side of York, between the city limits and the new U. S. Route 30 Bypass. This is about 0.7 mile (1.1 km) northeast of the Pa. Route 74 exit on U. S. 30 Bypass. The best mineralization was observed on the west side of the quarry about 50 feet (15 m) below the surface.

B. LATITUDE N: 39° 58′ 21″ LONGITUDE W: 76° 45′ 46″

C. TOPOGRAPHIC MAP: West York $7\frac{1}{2}$-minute quadrangle.

3. *Host Rock:* Stose and Jonas (1939) have mapped the area as Cambrian Ledger Formation, a coarse crystalline pure dolomite. The Ledger is roughly equivalent to the upper part of the Tomstown of the Great Valley and to the Shady dolomite of Austinville, Va. (Stose and Jonas, 1939, p. 58-59).

4. *Estimated Total Amounts of Ore Metals:*

A. <1 g:
1-1000 g:
1-1000 kg: Cd, Cu
>1000 kg: Zn

B. ASSAYS: A visual examination of 60 square feet of bench floor, constituting the best exposed mineralization, suggests an average of about 3% Zn for this area, but the grade is quite variable.

5. *Minerals Observed and Relative Amounts:*

A. ECONOMIC

Major:	Sphalerite (mostly golden with thin dark rims)
Minor:	Aurichalcite, malachite, smithsonite
Trace:	Hemimorphite, greenockite, hydrozincite, chalcopyrite

B. GANGUE

Major:	Dolomite
Minor:	
Trace:	Pyrite (pyritohedrons and cubes), goethite, calcite, quartz

6. *Paragenesis:* Massive ore: dolomite, quartz, sphalerite, calcite, and pyrite. In vugs: dolomite, dark sphalerite, quartz, and light sphalerite.

7. *Geologic Description:* The York Stone and Supply Company new (north) quarry lies in a complexly faulted area of lower to middle Cambrian carbonates. Bedding within the quarry appears to dip southwest at about 15°. There are no obvious faults in the mineralized portion of the

quarry and a post-blasting N-S vertical fracture set[1] appears unrelated to the zinc sulfide.

The host rock to the sphalerite is a pure, coarse crystalline (1-2 mm), light-gray to white dolomite which resembles the Ledger Formation. Along with these massive dolomite beds which comprise the bulk of the rock exposed in the quarry, are at least two sections of 15- to 20-foot- (5-6 m) thick beds of reportedly high-calcium, dark-blue-gray limestone resembling the Kinzers Formation and reported to contain the appropriate fossils. There is little evidence for thrusting between the dolomite and limestone sections. Possible interpretations include selective replacement of Kinzers limestone by secondary dolomite or facies relations between Ledger dolomite and limestone representing transitional, deeper water Conestoga facies (Rodgers, 1968). Regional mapping by Stose and Jonas (1939) suggests that most of the Cambrian carbonate section to the southeast is displaced by Conestoga facies. The main sphalerite show occurred about 20 ± 10 feet (6 ± 3 m) stratigraphically above the 15-foot (5 m) dark-gray limestone exposed in the bottom of the quarry.

Relations within the mineralized area are obscure. After carefully excavating and washing the mineralized area, it appeared to be a roughly horizontal lens 4 feet 10 inches (1.5 m) across, greater than 13 feet (4 m) long (it continued beyond the bench edge to the east and was only excavated for 13 feet in from the edge), and based on examination of the bench edge, less than 5 feet thick at present. The zone of richest, coarse (two inch = 5 cm grain size) sphalerite and white recrystalline dolomite trended S88E, but thc zone was so irregular as to make the measurement of dubious value. In general, the overall mineralized zone appeared to be partly localized within a particular bed, but also to trend northwest-southeast. Reports of additional sphalerite from the next higher and lower benches also tend to suggest this orientation, but additional washed exposures will be needed to establish the orientation.[2]

Because of the observed boulders up to 4 feet (1.2 m) in diameter estimated to contain 10% sphalerite and a possible identical facies relation to the Austinville, Virginia district (Brown and Weinberg, 1968), exploration is warranted. The physical appearance of the sphalerite, the similar host rock, and occurrence on the continuation of the Chickies anticline all suggest that the York Stone and Supply Company occurrence is genetically related to the old Bamford mine in Lancaster County.

1. Possibly present as incipient fractures prior to blasting.
2. A visit by D. T. Hoff in late August 1976 revealed a N60° W trending continuation to the next bench. In the bench highwall, a 4-foot- (1.2 m) wide zone of 1-2% Zn was exposed.

ORDOVICIAN OCCURRENCES

15. CORRELL or SAUCON MINE, LEHIGH COUNTY

(Former Zinc Producer With Low-Grade Reserves)

1. *Name:* Correll mine owned by Leon Reiss and William Polak of Leamon Roofing and Sheet Metal.

2. *Location:* A. The Correll open pit is located 0.15 mile (0.25 km) northwest of the intersection of East Saucon Valley Road with Old Bethlehem Pike, Friedensville. It is shown as a quarry 0.5 mile (0.8 km) northeast of the presently operating New Hartman shaft of The New Jersey Zinc Company. The open pit is about 400 feet (120 m) north-northwest of the Leamon Roofing building, Upper Saucon Township, Lehigh County. Underground workings extend southward beneath E. Saucon Valley Road, and extend westward to connect with the 19th century and present New Jersey Zinc Company New Hartman mines (Figures 32 and 33).

B. LATITUDE N: 40° 33′ 35″ LONGITUDE W: 75° 23′ 54″ (Open Pit)

C. TOPOGRAPHIC MAP: Allentown East $7\frac{1}{2}$-minute quadrangle.

3. *Host Rock:* The significant, known mineralization in the Friedensville area is in Rickenbach Formation of Lower Ordovician age (A. A. Drake, personal commun., 1974). The Rickenbach Formation, a silty and sandy, medium-dark-gray, crystalline dolomite with some boulder conglomerate and sedimentary breccia, forms the base of the Beekmantown Group in this area (Drake, 1965). The Rickenbach Formation is the lateral equivalent of the Stonehenge limestone and Larke dolomite of central Pennsylvania. The Trihartco Marker is a convenient marker bed of dark colored, sandy dolomite within the ore zone (Callahan, 1968).

No limestone was observed in the open pit. Black chert is common on the dumps, but was not observed in place. Beneath the ore horizon, clay-carbon residues are sufficiently abundant to give a black color to bedding surfaces.

4. *Estimated Total Amounts of Ore Metals:*

A. <1 g:
1-1000 g:
1-1000 kg: Cd
>1000 kg: Zn (probably well over 10 times this)

B. ASSAYS: No channel samples for chemical assay were collected, but the lowest 3 feet (1 m) of ore is a very high grade (>25% Zn) replacement of thin-bedded dolomite. Above this, there is 5 feet (1.5 m) of a fair grade (approximately 5% Zn) ore in breccia and another 12 feet (?, 4 m) of probably mineralized, but inaccessible breccia.

5. *Minerals Observed and Relative Amounts:*

A. ECONOMIC[1]

Major:	Sphalerite (gray to yellow, the former finer-grained)
Minor:	Greenockite, hemimorphite, smithsonite
Trace:	

B. GANGUE:

Major:	Dolomite (white to gray cleavages), pyrite (cubic and cuboctahedrons)
Minor:	Calcite (white cleavages and fibers)
Trace:	Quartz (colorless and milky)

No chert, chalcopyrite, galena, or microcline was observed in samples from the east footwall of the Correll open pit.

6. *Paragenesis:* Solution of rock dolomite and accumulation of clay-carbon residue; gray sphalerite, pyrite and dolomite; deformation and slickensiding; dolomite, quartz, calcite and lemon-yellow sphalerite. The relative order of pre-deformation mineralization was not determinable from hand specimen and may have reversed to form the sphalerite and pyrite bands in the crustification. Pre-deformation vein quartz is probable, but was not observed. In the gash veins, calcite forms the cores, and is therefore apparently younger.

7. *Geologic Description:* Callahan (1968, p. 101) ". . . shows the structure in the vicinity of the mines to be a southwesterly plunging (18°), overturned anticline, with vertical north limb at the Ueberroth mine, and a moderately inclined south limb (25°) at the Triangle, Correll, and New Hartman mines."

Drake (1970) believes that rocks of two major nappes, the Musconetong and the Lyons Station-Paulin's Kill, are in fault contact along the roughly N-S trending Black River fault[2] (see Figure 2 from Callahan, 1968). Based on the stream sediment data of Rose (1971) and a few follow-up samples collected by the author for Rose, zinc mineralization may exist on both sides of the Black River fault in northern Saucon Valley. If the ores are pre-Taconic as assumed by Callahan (1968) and Metsger and others (1973), it is likely that the Beekmantown Group rocks on both sides of the Black River fault are closely related.

The north side of the Correll open pit is the footwall of the ore body, in this case, a bedding surface or dip slope. Bedding here is variable, but has an average attitude of N72W, 32S. This footwall bed is a shaly dolomite which appears black from clay-carbon residues on bedding and nearly bed-parallel stylolites. There is a 15-foot (5 m) × 5-foot (2 m) slickenside plane with an attitude of N78E, 47S. The slickensides trend N55° W and the ore

1. The main ore in the original 18th century operation was hemimorphite, probably with some smithsonite. The known oxidized ore was soon largely mined out, and sphalerite was recovered following this.

2. Drake (personal commun., 1973) may have located his Black River fault differently from Callahan.

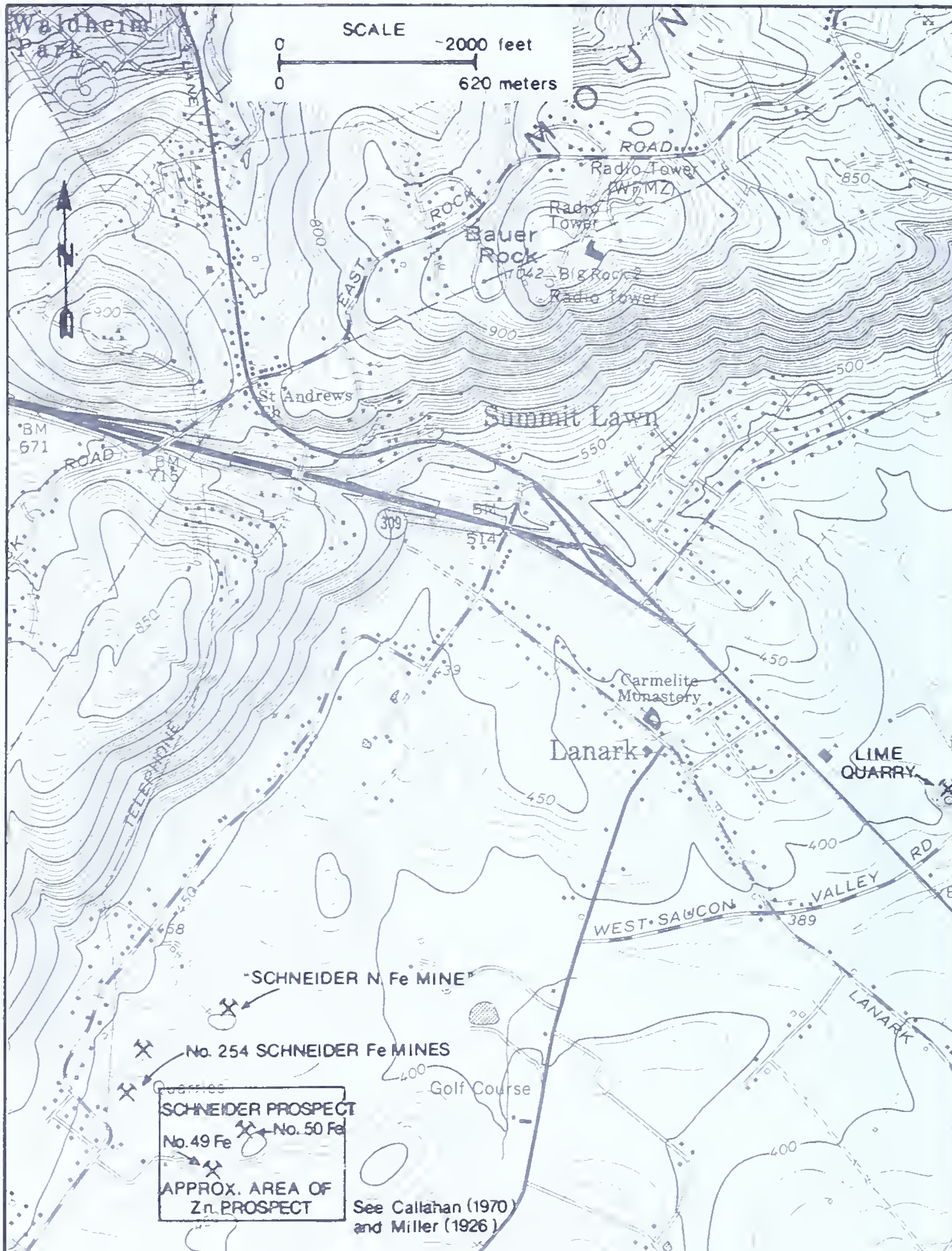
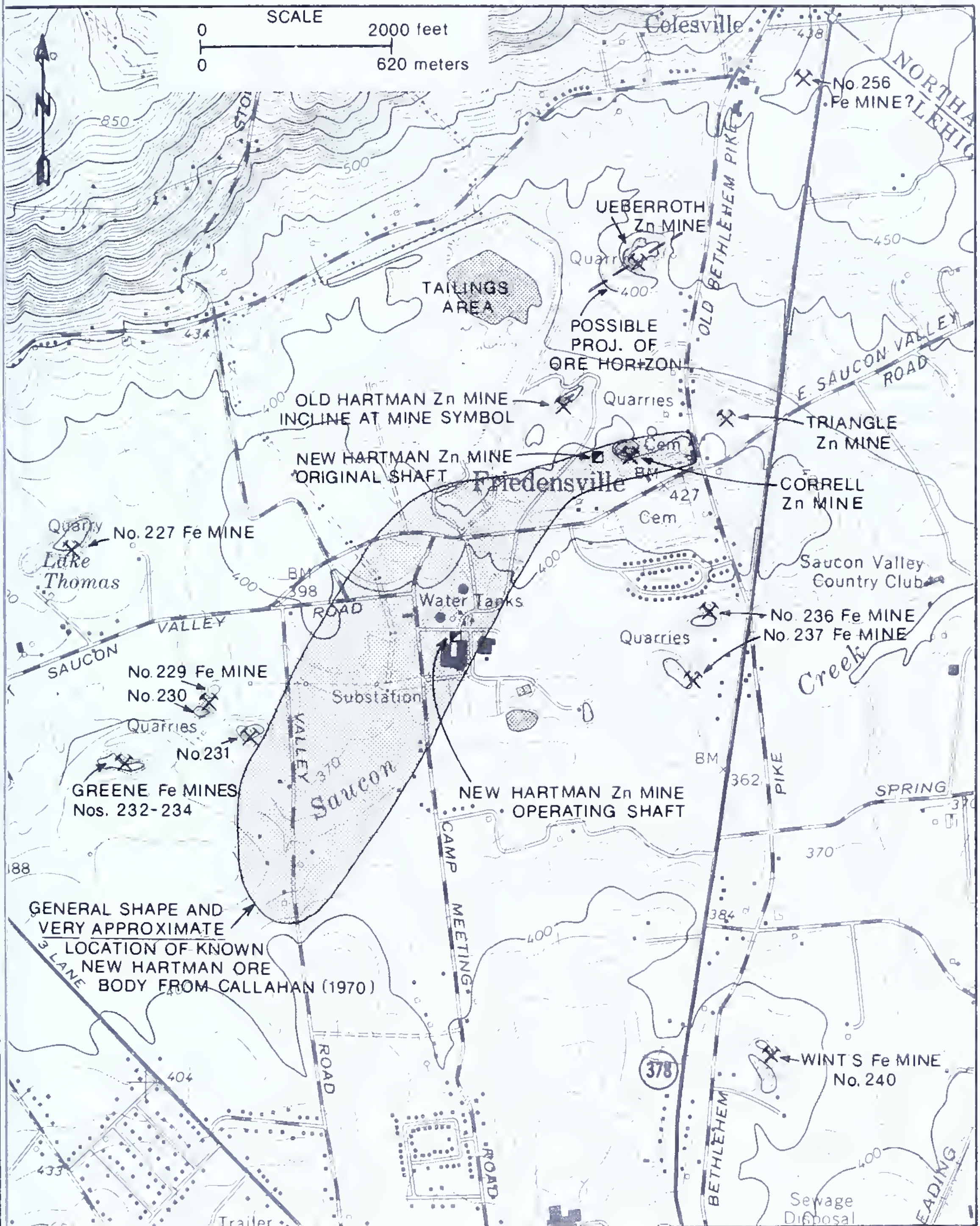


Figure 32. Zinc and iron mines (numbers from



Miller, 1926, 1941) in the Friedensville area, Lehigh Co.

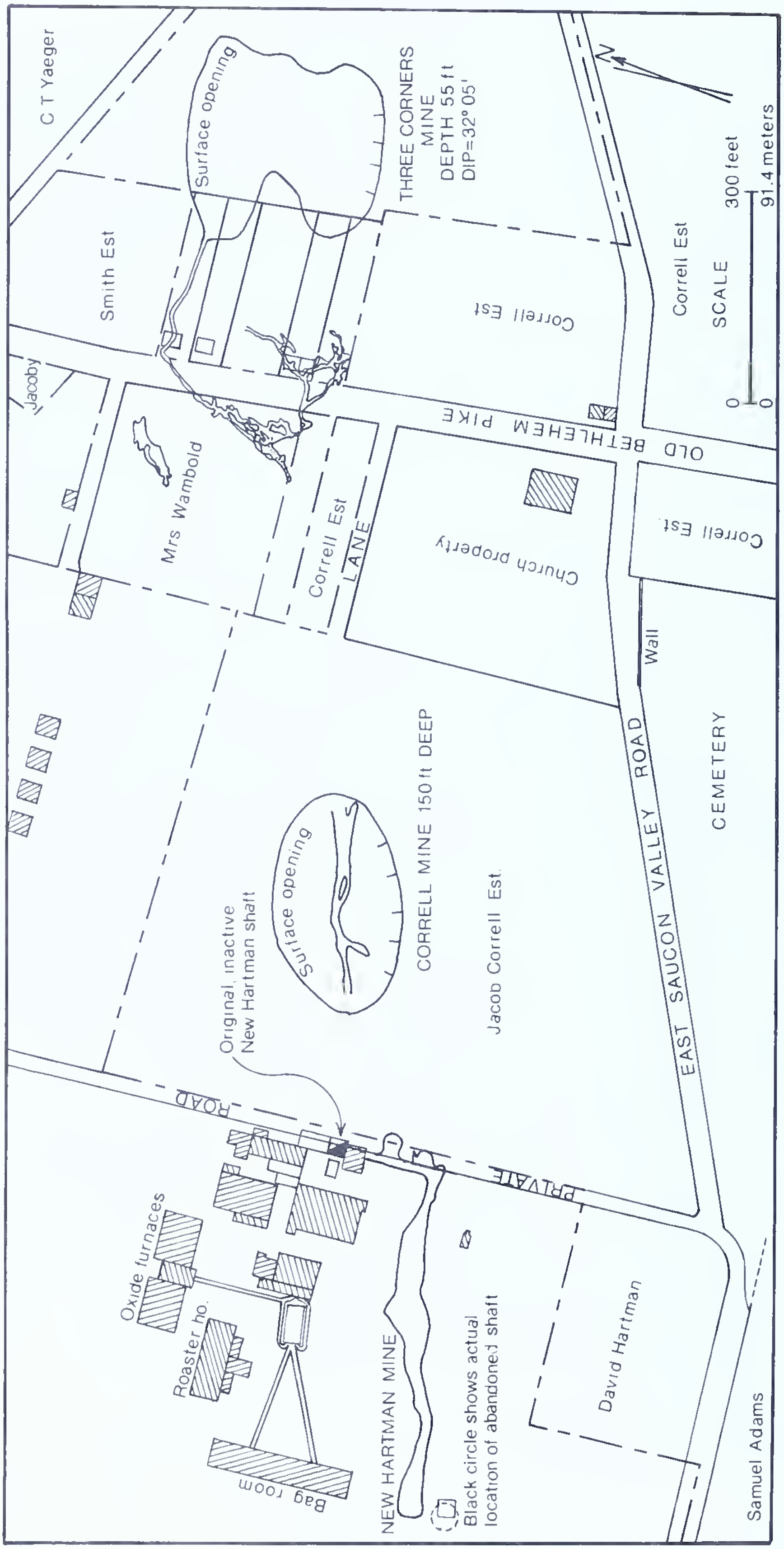


Figure 33. Correll (Saucon), Triangle (Three Corners Mine, Three Cornered Lot) and original, inactive New Hartman mines, Friedensville, Lehigh Co. (Miller, 1924, and The New Jersey Zinc Co.).

has had an apparent relative slip movement in this direction relative to the barren footwall itself.

Pyrite is abundant in all of the walls of the open pit, and weathering has resulted in considerable limonite staining. Thick, colorful crusts, probably mixtures of various sulfates, coat the undersides of ledges in the southeast corner. Most sphalerite-pyrite veins trend northeast and are subvertical. Those in the footwall proper trend N26 ± 4E, are subvertical and usually ½- (1 cm) to 1-inch (2.5 cm) thick. Bedding in the barren footwall just beneath good ore at the east end of the pit has an attitude of E-W, 40S. Here in the extreme east end, as elsewhere on the dip slope which forms the north wall of the open pit, there has been considerable solution along bedding leaving a lot of clay-carbon residue over which the ore has slipped northwest. Pyrite, some with calcite-quartz pressure fringes, but not sphalerite, is abundant in the clay-carbon-rich dolomite beds.

One distinctive bed in the footwall beneath the ore weathered to a gray-buff color, but is a dark crystalline dolomite when fresh. It is 8 inches (20 cm) thick, finely bedded, and contains approximately bed-parallel stylolites, but less clay-carbon than the beds just above and below. It is somewhat sandy, and based on abundant gash veins was competent with respect to the enclosing beds. The gashes, composed of dolomite, calcite, quartz, and a trace of lemon-yellow sphalerite, cut cleanly across the stylolites, but do not continue into the beds above or below. These relations suggest that solution along bedding preceded deformation, but that zinc mineralization was either associated with deformation or already present for remobilization into gash veins. In addition to gash veins, this bed is offset 5 inches (13 cm) at one place.

Miller (1924, p. 91) reports that Clark (sic) (1882) described the Correll mine as quoted below. Clark (sic) (1882) does not include this, but the information below is not readily available elsewhere.

> It was actively worked as early as 1859 and much of the time between that date and 1881, but since that time it has furnished little ore. The mine produced less oxidized ore in proportion to the sulphide ore than did the Ueberroth mine. It was worked by open cut until 1876, after which underground mining predominated, and when work ceased its depth was 200 feet. The limestone strata and the principal ore veins which lie between them dip to the south at angles that range from 30° to 40°. The limestones are regular and show few effects of disturbance or of solution.
>
> In 1876 a 12-foot vein of sulphide ore was being worked. At greater depth this width increased to 40 feet and in one place to 50 feet. The whole length of working in the Correll mine was about 700 feet along the strike. The veins were worked to the western limits of the property of the Correll estate and are continued in the New Hartman mine.
>
> The open pit of the Correll mine, which is now partly filled with water, measures approximately 200 by 300 feet.

Clerc (1882, p. 363-364) does include the following:

> A face of blende was uncovered at the western extremity of the open pit, and the ore was followed under a heavy cap of limestone for a distance of 250 feet up to the property of the Lehigh Zinc Company on the west. On this property it was reached at a depth of 110 feet, under 100 feet of solid limestone, and was followed 150 feet farther on the course of its strike. . . .
>
> The workings of these two mines (Correll and Hartman), taken together, show a remarkable regularity of width, pitch, and course, and the deposit is clearly shown to be a large chimney or chute of ore of irregular cross section, which, however, preserves a lenticular shape, the longer axis of which is about 60 feet, and pitches to the south at an angle of about 30°; the transverse axis measures about 30 feet. The axis of the body dips to the southwest with a slope of about one foot in four.

At present, the deep open pit is 225 feet (68 m) long in an E-W direction and 100 feet (30 m) wide in a N-S direction, but some back-filling has occurred. There are two inclines on the south side of the pit; and based on exhalation of fog, both are connected to significant underground workings. The western incline entrance is boarded over, whereas the eastern is open at the entrance, approximately 20 feet (6 m) wide and 10 feet (3 m) high, but partially back-filled with fine gravel. There are two adits from the bottom of the open pit in its extreme eastern end. One of these trends S23W for an estimated 50 feet (15 m) and the other trends N68E for an estimated 15 feet (5 m).

Miller (1924) reported 50 tons of ore per day from 1876 to 1881, the period of underground mining. This yields an approximate total of 75,000 tons for the underground workings of the Correll. The open pit dimensions suggest a possible ore block approximately 10 feet × 200 feet × 100 feet (3 × 60 × 30 m), yielding an additional 30,000 tons which could have been produced. If this ore contained approximately 20% Zn as the author believes probable, the present market value for production from the Correll would be between 50 and 75 million dollars.

Diamond core drilling by the U. S. Bureau of Mines revealed extensive trace and low-grade mineralization south and east of the open pit. Drill hole number 1 intercepted 1.89% Zn from 275 to 302 feet (84 to 92 m), drill hole number 2 intercepted 3.38% Zn from 216 to 225 feet (66 to 69 m), and 1.81% Zn from 236 to 254 feet (72 to 77 m), drill hole number 3 intercepted 1.66% Zn from 557 to 576 feet (170 to 175 m), drill hole number 4 was drilled just north of the ore horizon, and drill hole number 5 intercepted 1.53% Zn from 272 to 322 feet (83 to 98 m), and 2.80% Zn from 337 to 347 feet (103 to 106 m). Estimating conservatively, it appears that a 20 feet (6 m) interval containing 1.8% Zn is probable over most of the Correll property. This would yield approximately 10 million tons with a present market value of 100 million dollars. At present prices, however, 1.8% Zn "ore" might yield little or no profit.

16. KEYSTONE MINE AREA, NORTH SINKING VALLEY, BLAIR COUNTY

(Former, Small Lead Producer)

1. *Name:* The Keystone mine is reported to be owned by Albert Stringer or George Espy. A sphalerite-bearing roadcut along Pa. Route 453 is owned by Narehood Bros., Inc., and others; a roadcut along Elk Run by C. and H. Eyer and a railroad cut by the Pennsylvania Railroad (now ConRail).

2. *Location:* A. The main, underground Keystone mine, occurrence No. 14 of Zeller (1949), is located 0.8 mile (1.25 km) northwest of the crest of Pine Hill, 1.25 miles (2.0 km) southeast of the intersection of Pa. Routes 453 and 550, 0.55 mile (0.85 km) southwest of Honest Hollow bridge over Little Juniata River (here the Blair-Huntingdon County line), and about 300 feet (90 m) southeast of Honest Hollow Road (see Figure 34).

Zeller's (1949) occurrence No. 10 is located on the southeast side of Elk Run Road in an outcrop at road level. This occurrence is 1.85 miles (2.9 km) due west of the crest of Pine Hill, 2.05 miles (3.1 km) south-southwest of the intersection of Pa. Routes 453 and 550, 1.70 miles (2.75 km) southwest of the junction of Elk Run with Little Juniata River; and exactly 0.50 mile (0.8 km) east of the west edge of the Tyrone 7½-minute quadrangle.

Zeller's (1949) occurrences Nos. 15 (Figure 35) and 17 and three better shows occur on the northeast side of Pa. Route 453, 1.1 miles (1.75 km) north of the crest of Pine Hill, and 1.2 miles (1.9 km) southeast of the intersection of Pa. Routes 350 and 550. The three largest occurrences in this roadcut occur 445 feet (136 m) S60E, 490 feet (149 m) S55E (Zeller No. 15) and 620 feet (144 m) N45W (Nittany Fm. sphalerite) from the intersection of Honest Hollow Road and Pa. Route 453. There are also traces of sphalerite and galena in the Nittany Formation 730 feet (220 m) and in the Bellefonte Formation 2000 feet (610 m) northwest of the same reference point. This roadcut is about 150 feet (45 m) northeast of the Blair-Huntingdon County line.

The weakly mineralized exposure along the southwest side of the Pennsylvania Railroad is located exactly 1.0 mile (1.65 km) due north of the crest of Pine Hill, 1.2 miles (1.95 km) southeast of the intersection of Pa. Routes 453 and 550, and 0.15 mile (0.2 km) south-southeast of Honest Hollow bridge over Little Juniata River. Trace sphalerite occurs 525 feet (160 m) southeast from the underpass of Honest Hollow Road beneath the Pennsylvania Railroad and trace galena 1130 feet (350 m) southeast of the same reference point.

Pyrite in "breccia" and rare sphalerite "eyes" in the Bellefonte Formation are exposed along the southwest side of Pa. Route 453, 525 feet (160 m) southeast of the Blair-Huntingdon County line on the bridge over Little Juniata River. This area is 0.7 mile (1.2 km) southeast of Shoenberger. Traces of slickensided orange sphalerite occur from 215 to 345 feet (66 to 106 m) southeast of the same county boundary.

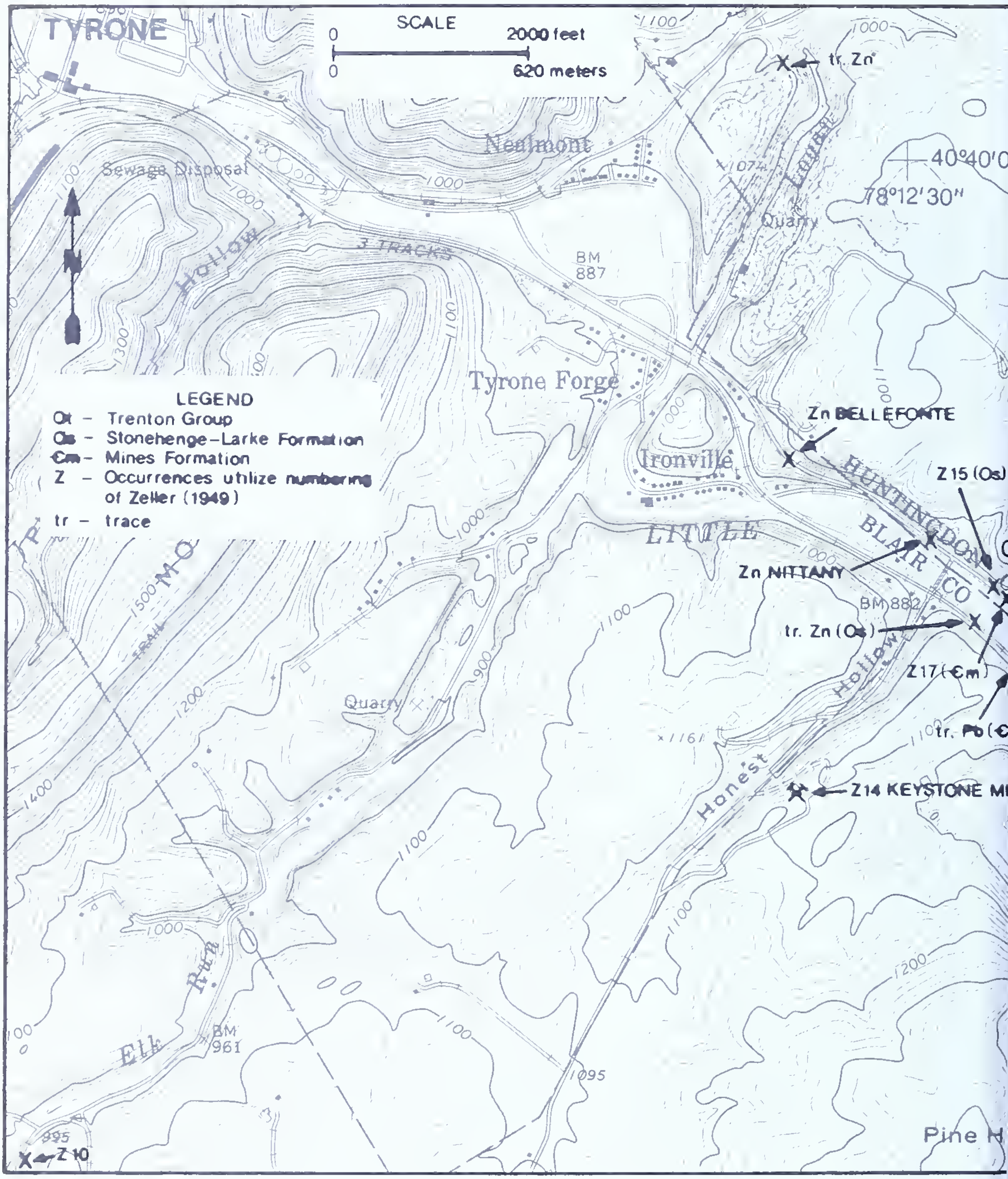


Figure 34. Zinc-lead occurrences, Keystone mine area, northern Sinking Valley, Blair and Huntingdon Counties.

Zeller's occurrences numbers 11 and 12 were sought but not found, whereas numbers 13, 16, 18, 19, and 20 were described as trace occurrences and therefore not sought.

Figure 35. Contorted bedding in lower Stonehenge Formation at Zeller occurrence number 15, Birmingham, Blair County. The notebook is in the plane of a small wedge fault.

The Keystone mine, Zeller's occurrence No. 10, the outcrop along the Pennsylvania Railroad, and the pyrite in "breccia" along Pa. 453 are in Tyrone Township, Blair County. Zeller's occurrence numbers 15 and 17, Nittany Formation sphalerite and Bellefonte Formation sphalerite are in Warriors Mark Township, Huntingdon County.

B.	LATITUDE N	LONGITUDE W
Keystone mine	40° 38′ 56″	78° 12′ 46″
Zeller No. 10	40° 38′ 20″	78° 14′ 26″
Bellefonte Fm. sphalerite	40° 39′ 30″	78° 12′ 46″
Nittany Fm. sphalerite	40° 39′ 21″	78° 12′ 26″
Zeller No. 15	40° 39′ 18″	78° 12′ 18″
Zeller No. 17	40° 39′ 16″	78° 12′ 16″
Pennsylvania R. R. sphalerite	40° 39′ 13″	78° 12′ 21″
Pennsylvania R. R. galena	40° 39′ 09″	78° 12′ 15″
Bellefonte Fm. pyrite in "breccia" and sphalerite eyes	40° 37′ 37″	78° 10′ 32″
Bellefonte Fm. slickensided sphalerite (in same cut as preceding location).	40° 37′ 38″	78° 10′ 34″

C. TOPOGRAPHIC MAP: All of the above occurrences are in the Tyrone 7½-minute quadrangle, a portion of which is included as Figure 34 of this report.

3. *Host Rock:* The host for mineralization in accessible portions of the Keystone mine is brecciated beyond recognition (Figure 36). Figure 6 of Moebs and Hoy (1959) shows that the Keystone mine area is in the Black River-Chazy Groups. but does not locate the mine proper. Their mapping was done before a 1:24,000 topographic base was available and before Larke Formation dolomite was given its present definition (Donaldson, 1959). Moebs and Hoy describe the middle Ordovician Black River-Chazy Groups as composed of thick-bedded, dove-gray limestone. This is consistent with the author's observation that the host is limestone rather than dolomite. Zeller (1949) stated that the mine was entirely within the Champlainian Group of various middle Ordovician limestones. The present author does not rule out the Stonehenge-Larke Formation or lithologically similar Warrior Formation as possible hosts.

Zeller has mapped the host to mineralization at his occurrence No. 10 as upper Bellefonte Formation. generally a thick-bedded. gray dolomite with minor chert. At the occurrence. the host is a medium-gray fine-grained dolomite with quartz nodules. a few with crystalline interiors.

The traces of sphalerite in the Bellefonte Formation along Pa. Route 453 north of Honest Hollow are in the lower third of that formation based on the map by Butts and others (1939). Structural complexities prevent precise stratigraphic determinations.

Ignoring the structural complexities. and assuming that the dip averages about vertical. the sphalerite and galena in the brecciated Nittany Formation 360 to 520 feet (110 to 160 m) northwest of Honest Hollow bridge occur about 260 to 420 feet (80 to 130 m) above the base of the Nittany Formation as it was defined by Donaldson (1959). According to him. the Larke-Nittany contact is about 100 ± 10 feet (30 ± 3 m) northwest of the projection of Honest Hollow bridge onto Pa. Route 453. Here, the Nittany is a medium-dark-gray (N4). medium to finely-crystalline dolomite which is shot through with veinlets of calcite and dolomite which do not exceed 1 mm in thickness. The host is darker than usual. probably due to the above-normal clay-carbon insoluble residue content accumulated by extensive post-lithification solution. Just below the sphalerite-bearing breccia. the dolomite is laminated.

Zeller's occurrence No. 15 is in a complexly folded lower Ordovician Stonehenge Formation. consisting of a thin-bedded. argillaceous limestone with abundant intraformational conglomerates (Figure 37) and stromatolites. From this occurrence, it is 57 feet (17 m) S50E to the uppermost beds of dolomite of the Spring Creek Member of the Stonehenge Formation. Here. the Spring Creek Member is the lowermost dolomite tongue of the Larke Formation. a dolomite facies equivalent of the Stonehenge. Donaldson (1959) measured a thickness of 20.5 feet (9 m) for the lower Larke dolomite tongue. Stratigraphically below this is the upper Cambrian Mines Formation. a crystalline cherty dolomite. Sphalerite occurrence

No. 15 is 80 feet (25 m) above the top of the Mines Formation. The present author also found a moderate amount of sphalerite 45 feet (14 m) northwest of Zeller's occurrence No. 15 proper (Figure 38). This is 100 feet (31 m) perpendicular to strike above the top of the lowermost dolomite tongue of the Larke Formation. If one ignores the considerable variation in dip, as apparently done by Donaldson, and assumes the 63SE general dip, this sphalerite is 90 feet (28 m) above the dolomite tongue or 120 feet (37 m) above the Mines Formation, making the host the lower Baileyville or upper Graysville Member of the Stonehenge Formation. This host is a brecciated limestone with very abundant clay-carbon residues. It strongly resembles the host in the Keystone mine, but unlike the Keystone mine, must, by definition, be Stonehenge Formation. The rock in the power line at the top of the roadcut is probably Trenton Group limestone, not Stonehenge Formation as mapped by Butts and others (1939) and Zeller (1949).

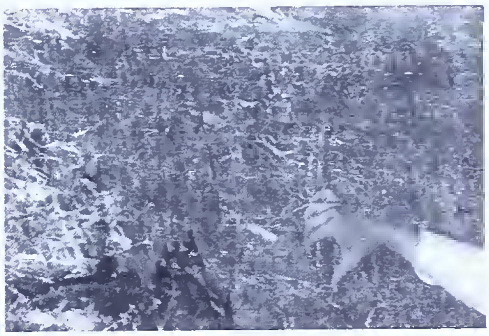


Figure 36. Calcite and trace sphalerite in tectonically brecciated limestone in the upper level of the Keystone mine. Compare this breccia with that in Figure 45 of rubble breccia from Friedensville and Figure 60 of tectonic breccia at the Scott Smith prospect.

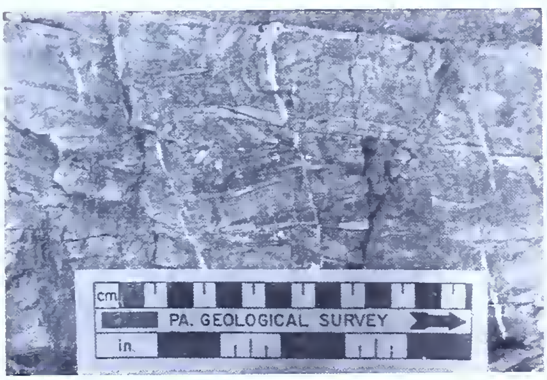


Figure 37. Flat-pebble conglomerate in Stonehenge Formation at Zeller occurrence number 15, Birmingham, Blair County. (Such rock should provide a suitable ore host.)

Figure 38. Sphalerite (see arrow) rimming calcite veins in Stonehenge limestone at Zeller occurrence number 15, Birmingham, Blair County.

The host for Zeller's occurrence No. 17 is dolomite of the upper Cambrian Mines Formation. The two best shows are 40 feet (12 m) and 70 feet (21 m; at utility pole number 26) southeast of the contact with the Larke-Stonehenge, which was defined by Donaldson (1959) as being 3 feet (1 m) southeast of a quartzose dolomite bed. The Mines Formation here is a dark, coarsely crystalline dolomite with black chert. Bedding is steep and apparently strikes perpendicular to Pa. Route 453.

The trace of galena observed along the Pennsylvania Railroad cut is in a dark, brecciated, cherty crystalline dolomite which is assumed (by the present author) to be Mines Formation, probably the lower part. The trace of sphalerite observed in the same cuts is in Stonehenge limestone 325 feet (100 m) northwest from the nearest outcrop of Mines Formation and 315 feet (96 m) southeast from the nearest outcrop of the middle tongue of the Larke dolomite lithofacies within the Stonehenge. Small-scale structures are very complex, but the middle of the lower limestone "member" of the Stonehenge is suggested as the host for this sphalerite occurrence.

The host for pyrite in "breccia," rare sphalerite eyes, and orange slickensides sphalerite is dolomite of the Bellefonte Formation (Figure 39). The pyrite in breccia (Figure 40) and sphalerite eyes occur 440 ± 25 feet (135

Figure 39. Orange-brown iron staining from decomposition of pyrite in the Bellefonte Formation. The normal light gray color of dolomite lacking a coat of "nature's yellow boy" is visible in the upper left hand corner. Photo taken on the southwest side of Pa. Route 453, 525 feet (160 m) southeast of Little Juniata River.

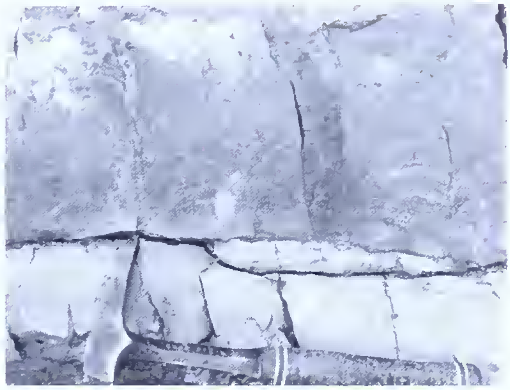


Figure 40. Algal stromatolites in dolomite of the middle of the Bellefonte Formation exposed in the southwest end of a roadcut of Pa. Route 350 over the Huntingdon-Blair County line. Photo taken just below the sphalerite and pyrite occurrence described in the text.

± 8 m) beneath the lowermost limestone bed used to define the base of the Milroy Member of the Loysburg Formation (Chafetz, 1969). The orange slickensided sphalerite occurs 575 ± 25 feet (175 ± 8 m) beneath the Milroy.

Note that Moebs and Hoy (1959) considered the Stonehenge Formation to be a 200-foot- (61 m) thick limestone, whereas Donaldson (1959) noted that Larke dolomite is really a facies equivalent of the limestone of the Stonehenge Formation. Donaldson thus obtained a thickness of 416.5 feet (126.9 m) for the Stonehenge Formation in this area. Moebs and Hoy apparently mapped the Larke dolomite facies as Mines and Nittany Formations. The outcrop width of Stonehenge Formation on Figure 6 of Moebs and Hoy is thus probably much narrower than it should be. For similar reasons, the outcrop width of the Nittany Formation mapped by Butts and others (1939) is too great.

4. *Estimated Total Amounts of Ore Metals:*

A.	<1 g	1-1000 g	1-1000 kg	>1000 kg
Keystone mine			As, Ag	Zn, Pb[2]
Zeller number 10[1]	Pb, Ba			
Bellefonte Fm. sp.		Zn		
Nittany Fm. sp.			Pb	Zn
Zeller's No. 15 + No. 17 (all occurrences in Larke-Stonehenge plus Mines along Pa. 453 near Honest Hollow)		Pb	Zn (upper end of range)	
Pennsylvania Railroad		Pb, Zn		
Bellefonte Fm. pyrite in "breccia" area	Pb			Zn

1. Zeller reports galena but no sphalerite. The present location is probably not identical to Zeller's.
2. At least 50,000 kg of Zn was produced.

B. ASSAYS: Platt (1881, p. 258-260) reports the following assays for ore from the various shafts in the Keystone mine area:

	Keystone smelter stock pile	Average of No. 2 shaft ore mined	No. 3 shaft ore	No. 4 shaft ore	No. 5 shaft ore	Kinch farm high-graded
Zn%	15.9	37.7	27.7	24.9	38.7	45.2
Pb%	51.6	5.4	.8	1.1	1.2	6.2

Platt (1881, p. 261) estimates that 1300 tons of primary 30% Zn ± Pb ore and 2000 tons of secondary 8% Zn plus Pb were produced at the Keystone mine by 1881. This may not include production from 18th century mining.

A substantial amount of ore containing 1 to 5% Zn plus Pb (visual estimates) remains in the walls of the Keystone mine, especially near the walls of the southern vertical shaft (see Figure 41).[3]

The Nittany Formation sphalerite occurrence is estimated to contain 0.1 to 2% Zn over a 160-foot (49 m) section through a tectonic breccia zone (not the most obvious breccia zone, which is barren).

A. V. Heyl (personal commun., 1973), U. S. Geol. Survey, reports 1.5 oz Ag/ton in pure-picked galena from the Keystone mine.

5. *Minerals Observed and Relative Amounts:*

A. ECONOMIC

	Major	Minor	Trace
Keystone mine	Sphalerite (yellow to brown)	Jordanite* (metallic rims on galena and discrete grains)	Anglesite, smithsonite, and cerussite
Zeller No. 10	Sphalerite (yellow-orange)	Hydrozincite, smithsonite	Galena
Bellefonte Fm. sp.			Sphalerite (yellow)
Nittany Fm. sp.	Sphalerite (golden-brown to lt. yellow, the latter fluorescent)		Hydrozincite, smithsonite, galena
Zeller No. 15	Sphalerite (yellow-orange)	Galena	

3. A. W. Rose, of The Pennsylvania State University, correctly noted in review that the author's "substantial amount" would seem trivial to a 2000 t.p.d. mill.


0
20
40 feet
0
12 meters
N
LEGEND
Strike and dip of mineralized vein
Stringer, generalized orientation
Horizontal mineralized vein
Fault, showing dip (82°) and bearing of slickensides (70°)
Mineralized rock
Filled workings
Head of raise, water-filled
Head of raise
Slope, chevrons point down
Replacement zone ~1 ft. thick
Apparently had been extensive replacement ore
Surface openings
6 ft.
10 ft.
Vein and replacement
75
75
75
63
83
30
82
70
(R.L Schmiermund & A.W Rose, 1969, R.C.Smith II & A.W.Rose, 1972)

	Major	Minor	Trace
Zeller No. 17	Galena sphalerite (yellow-orange)	Smithsonite	
Pennsylvania Railroad			Galena, sphalerite
Bellefonte Fm. pyrite in breccia			Sphalerite (honey-yellow and orange), galena

B. GANGUE

	Major	Minor	Trace
Keystone mine	Calcite	Pyrite, "flow-stone" probably aragonite, (Figure 42)	Dolomite, barite, gypsum
Zeller No. 10	Calcite	Quartz	Barite
Bellefonte Fm. sp.			
Nittany Fm. sp.	Dolomite	Calcite	Pyrite
Zeller No. 15			Pyrite
Zeller No. 17	Dolomite		Quartz
Pennsylvania Railroad	Calcite		
Bellefonte Fm. pyrite in breccia area	Pyrite (disseminated in "breccia" matrix)	Quartz (milky, with sphalerite eyes)	

6. *Paragenesis:* For Keystone mine highly uncertain, but possibly: tectonic deformation, solution and accumulation of clay-carbon, barite, calcite, pyrite, sphalerite, galena, tectonic deformation, jordanite and dolomite.

7. *Geologic Description:* The north end of Sinking Valley is one of the best studied and least understood areas of central Pennsylvania. Cross sections for this area have been drawn by Platt (1881), Butts and others (1939), Stose (in Butts and others, 1939 p. 78), Zeller (1949), Fox (1950), Moebs and Hoy (1959), and Gwinn (1964). Each of these seven cross sections is different. Although the cross section of Gwinn (1964) is the most recent, Moebs and Hoy (1959) had direct access to approximately three miles of diamond drill core and cannot therefore be discounted as the probable best reference on the upper 500 feet.

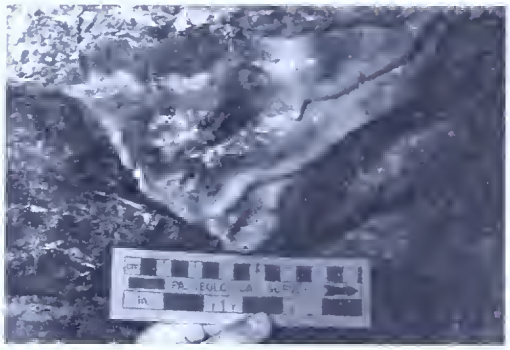


Figure 42. Calcium carbonate flowstone deposited on the walls of the Keystone mine since the close of operations about 100 years ago. In places, the flowstone has encapsulated and preserved insects.

The Keystone mine area is located on the crest of the Nittany arch, a 35-mile-wide and 80-mile-long (56 × 129 km) asymmetric anticlinorium with an overturned northwest limb forming Bald Eagle Mountain (Butts, 1939). The axis of the Nittany arch trends northeast-southwest and in the Keystone mine area is cut by a northwest-trending lineament of disturbed structure and mineralization (Smith and others, 1971). The northwest-trending lineament is presently occupied by the Little Juniata River and therefore highly visible on ERTS photos as, for example, the January 10, 1973, channel 7 imagery.

Moebs and Hoy (1959) indicated that the mine area is underlain by the gently arched Sinking Valley thrust fault, roughly concentric to the curvature of the earth. Ordovician and Silurian sandstones and shales are exposed northeast and east of the mine in fensters through the Sinking Valley fault. The Birmingham and Honest Hollow faults are southeast-dipping thrusts which splay off the Sinking Valley thrust at depth. Together, the Birmingham and Honest Hollow faults have dragged and brecciated a horse of Black River-Chazy limestone (or Stonehenge Formation or Warrior Formation) between them. The Keystone mine itself is within this horse, but some mineralization extends into the Gatesburg Formation above (geochemical data on soil samples, A. W. Rose, personal commun., 1972) and Stonehenge and Mines Formations below (Zeller's occurrences 15 and 17 as well as the Pennsylvania Railroad cut).

The presence of at least traces of sphalerite and galena in upper Cambrian through Middle Ordovician hosts suggests that some mineralization is post-deformation. In order to mineralize all these hosts, one possibility is that the Sinking Valley thrust was a primary conduit for hydrothermal solutions localized by secondary splays. However, movement of solutions through a major thrust should be difficult. Problems also arise in thoroughly brecciating the incompetent limestone in the mine and in accounting for mineralization on both sides of the crest of the Sinking Valley fault. Hydrothermal solution movement toward the crest of the fault from two directions seems unlikely.

A. W. Rose (personal commun., 1974) offers an alternative path or primary conduit for hydrothermal solutions. He believes that steeply dipping,

highly fractured Silurian Tuscarora quartzite and Ordovician Bald Eagle (Oswego) sandstone present beneath the Sinking Valley thrust would serve as excellent conduits as they apparently have in the Milesburg Gap and Mapleton areas. Moebs and Hoy (1959) encountered Reedsville and Juniata Formations in drilling and these as well as the Tuscarora and Bald Eagle Formations are exposed in nearby windows. According to Rose's model, metals would be precipitated upon passing through the Sinking Valley thrust and encountering suitable carbonate rocks. The report of sphalerite, galena, and pyrite in Tuscarora quartzite nearby tends to support this theory. These sulfides were reported to have been encountered in a 15 foot- (approximately 5 m) thick float block of quartzite east of Tyrone in core drill No. 19 for L. R. 1061, ramp H, section 12 (A. Sternagle, personal commun., 1973).

Some galena, sphalerite, and calcite grains in the Keystone mine and sphalerite at the pyrite-in-"breccia" occurrence have strongly curved cleavage surfaces. Also, pyrite replaces the matrix of a solution breccia or intraformational conglomerate in dolomite of the Bellefonte Formation, 300 feet (91 m) southeast of the expansion joint in the Pa. Route 453 bridge over the Little Juniata River on the apparently unfaulted eastern limb of the Sinking Valley anticline (see p. 94). The above relations suggest that at least some mineralization may be pre-deformation. Miller (1924, p. 15) entered the Keystone mine in 1921 and noted "Slickensides were observed on the ore and the wall rocks, showing movement subsequent to deposition of the ore." As a guide to prospecting, however, the idea that much of the mineralization is post-deformation (as suggested in the previous paragraphs) seems to be a potentially more fruitful assumption. If this assumption is correct, then drilling to the Sinking Valley thrust is warranted along its crest, especially beneath the Little Juniata River; above Tuscarora and Bald Eagle Formations as suggested by the model of Rose; and perhaps through the interbedded limestone and dolomite of the Warrior Formation a few miles to the northeast. Moebs and Hoy (1959, p. 1087) suggest that ". . . the Sinking Valley fault becomes progressively deeper to the southwest, which indicates that the 'arch' of the fault, like the axis of the anticline, plunges southwest."

Plate 2 contains a plane table map of the Keystone mine area in 1973 by R. L. Schmiermund and C. D. Palmer. It agrees well with the tape and compass map of J. Speece and M. Cullinan (Speece and Cullinan, 1972) except that the latter map requires a 180° rotation. The latter reference includes a description of some mineralized cave (?, mine) passages in the lower level which are apparently now caved-in.

Figure 41 is a tape and compass map of the upper level of the easternmost (main) Keystone mine made by R. L. Schmiermund and A. W. Rose in 1969. The bearings of the drifts were checked and the locations of sphalerite and galena were added in 1972 and 1973 by A. W. Rose and the author.

Zeller noted that mineralization in the main Keystone mine lies along joints which trend roughly north-south. This is not obvious in the mine, but is to some extent consistent with Figure 41. In the vicinity of Zeller's occurrence No. 15, relations are clearer because of less tectonic brecciation. In the western part of occurrence 15, the local control on sulfides in veins perpendicular to bedding seems to have been a reduction near clay-carbon-pyritic stylolites up to 1 mm thick. (Clay-carbon insoluble residues are also very common in the main Keystone mine.) In the eastern part of occurrence 15, calcite gash veins $\frac{1}{8}$-$\frac{1}{4}$ inch (3-6 mm) wide are roughly perpendicular to bedding and cannot be traced for more than 6 inches (15 cm). In the wider gash veins, the sphalerite is concentrated along the gash-limestone wall rather than well within the calcite (see Figure 38). At both the northwest and southeast parts of the occurrence, sphalerite is estimated to be about 20 times as abundant as galena.

Three of the seven shaft locations of Platt (1881) could not be correlated with Plate 2 of this report. Because Platt describes the adit as trending S22W rather than southeast or northwest, the author is doubtful about the accuracy of Platt's published descriptions.

Platt reported galena, sphalerite, hemimorphite, and barite on the hill across Honest Hollow Road northwest from the Keystone mine adit. The barite occurred in two vertical veins which trended northeast-southwest and were 6 inches (15 cm) and 3 inches (8 cm) wide. A. V. Heyl (personal commun., 1976) observed a large area of yellow chlorotic vegetation in this area during his visit in 1957.

During the present study, ore containing 5-10% Zn was observed on the upper level of the Keystone mine near the southern shaft shown in Figure 43, and in the "abyssal stope" (Figure 44) of Zeller. Small amounts of additional ore could exist beneath the old mine. Residents report that some "ore" was encountered in a southeast-trending drill hole located at the base of the hill, about 200 feet (60 m) west-northwest of the workings shown in Plate 2. Platt (1881) reported Zn assays ranging from 31 to 48% and Pb from 1 to 5%, but these were probably the result of very selective mining or even hand sorting. The far more speculative deep drilling of the crest of the Sinking Valley fault to the southwest or beneath the Little Juniata River may also be warranted. The report of Moebs and Hoy (1959) suggests a substantial drilling program by The New Jersey Zinc Company, but only the geological results were published.

The Nittany Formation sphalerite occurrence, 360 to 520 feet (110-160 m) northwest of the projection of Honest Hollow bridge onto Pa. Route 453 is in tectonic breccia. The median bedding right at the sphalerite occurrence is N26E, 44SE, but readings in this area are highly variable.

The Bellefonte Formation pyrite-in-"breccia" occurrence is on the southeast limb of the anticline where bedding is N52E, 30SE. Neither the pyrite nor the rare sphalerite in quartz eyes at the same general location appear

Figure 43. View across vertical shaft of Keystone mine to an area of ore on the left side of photo.

Figure 44. Entrance to "abyssal stope" of Keystone mine, Birmingham, Blair County. The black area to the right of the geologist's feet is a water-filled incline about which nothing is known.

to be of epigenetic origin. Traces of strongly slickensided orange sphalerite occur in this same exposure; along irregular fractures, in brecciated gray chert with a relict concentric structure, and along a N40W, 85SW slickensided joint set. This suggests that some sphalerite was present before deformation had ceased. Intraformational conglomerate is ruled out for the pyrite host because the "breccia" is not confined to particular beds, and traces of normal solution-collapse breccia (as well as more common tectonic breccia) do occur in the lower part of the Bellefonte Formation on the northwest side of the river, 1100 feet (340 m) northwest of the county line. Perhaps the peculiar pyritic "breccia" represents settling over a normal solution-rubble collapse. The presence of early trace sphalerite stratigraphically beneath the pyrite is encouraging.

Recently, traces of dark sphalerite were reported from the Narehood Brothers quarry located 0.6 mile (1 km) northeast of the Pa. 550-453 intersection (J. P. Ambler, personal commun., 1976). This extends the known limits of zinc mineralization farther northeast.

17. NEW HARTMAN MINE, LEHIGH COUNTY

(Active, Very Large Zinc Producer With Reserves)

1. *Name:* The New Hartman mine is owned by The New Jersey Zinc Company. This is the second shaft by this name in the district.

2. *Location:* A. The operating New Hartman shaft is located 3125 feet (950 m) S57W of the crossroads at Friedensville and 3175 feet (965 m) N65W of Pa. Route 378 over Saucon Creek (Figure 32). The equipment access incline is located on the south side of the southeast half of the Old Hartman open pit. The portal of this incline is located 1550 feet (475 m) N61W of the crossroads at Friedensville. Information on the surface location of the center of the New Hartman ore body has not been published, but from the plunge, surface outcrop, and shaft depth, it would probably be located southwest of the operating New Hartman shaft. The original New Hartman shaft, now sealed with steel doors, is about 30 feet (9 m) west of the apparent Leamon - N. J. Zinc property line and N86W of the spire of the church at Friedensville. This original shaft may have been developed to furnish evidence that the former operators of the Correll mine were removing ore from beyond their property.

B.

	Active New Hartman Shaft	Entrance to Incline	Original New Hartman Shaft
LATITUDE N:	40° 33′ 16″	40° 32′ 40″	40° 33′ 34″
LONGITUDE W:	75° 24′ 18″	75° 24′ 02″	75° 23′ 58″

C. TOPOGRAPHIC MAP: Allentown East 7½-minute quadrangle.

3. *Host Rock:* Lower Ordovician Rickenbach Formation at the base of the Beekmantown Group. The ore is localized in a series of dark sandy dolomite beds about 900 feet (275 m) (Callahan, 1968) beneath the top of the preserved Beekmantown Group in this area. Where the Ontelaunee Formation has not been removed by erosion, this interval would be greater. According to Callahan (1968), the ore horizon begins about 120 feet (36 m) above the top of saccharoidal dolomite in the Allentown Formation. The intervening 30 to 40 feet (9-12 m) is occupied by the Evans Marker, a thin-bedded dolomite with anastomosing shaly laminae. Walter Granlund (personal commun., 1973) reports the barest traces of sphalerite in the Evans Marker.

4. *Estimated Total Amounts of Ore Metals:*

A. <1 g:

1-1000 g:

1-1000 kg:

>1000 kg: Zn, Cd

From 1958 through 1975, the Old Hartman-New Hartman-Correll ore body produced a total of about 475,000 tons (430,000 metric tons) of zinc from 6 - 6.5% ore mined through the New Hartman shaft[1]. Deepening of the main shaft from 1972 through early 1974 forced a decline in production. If alleged environmental and technical problems can be solved, total production could probably be doubled, making the mine one of the most

1. Based on totals from U. S. Bureau of Mines Minerals Yearbook and Metsger and others (1973, p. 4). Metsger reports an average grade of 6.4% Zn.

important producers in the United States, but water problems may hamper this. Unrecoverable zinc ore in pillars, 1 - 2% "ore" in the hanging wall, unmined oxidized pockets and good ore in bad ground will probably force the unfortunate loss of an additional few hundred thousand tons of zinc.

Callahan (1968, p. 104) reports an analysis of pure sphalerite as follows: 66.2% Zn, 0.40 Fe, 0.05 Cd, 0.36 SiO_2; Ga 10-100 ppm, Ge 10 ppm, and Cu, Pb, and Mn each 1 ppm.

B. ASSAYS: Ore was reported to average 6.5% zinc for the period 1958-1964 (Callahan, 1968). Continuation of a strong market and dwindling global supply could permit future grade reduction. Visual estimates on the 900 through 1170 levels suggest that selected areas of footwall ore contain up to 30% Zn, the lower 50 feet (15 m) of ore contains about 6 - 12% Zn, and the upper 50 feet about 1 - 6% Zn. Rock beneath the footwall is essentially free of sphalerite, whereas the grade at the hanging wall tapers off gradually at an unknown rate. In general, the ore grade is better on the west side of the ore body with grades on the east decreasing to 2 - 3% Zn, which must be blended. The drill hole data of White and Bell (1948) also tend to confirm a decrease in ore grade to the east.

5. *Minerals Observed and Relative Amounts:*

A. ECONOMIC[2]

Major:	Sphalerite (fine- to medium-grained, gray with a conchoidal fracture and rarely a colloform banding), hemimorphite
Minor:	Sphalerite (fine-grained, yellow)
Trace:	Sphalerite (lemon-yellow crystals and orange- to reddish-brown cleavages), greenockite (thin stains on upper levels), chalcopyrite(?), sauconite, smithsonite (Metsger and others, 1973).

B. GANGUE

Major:	Pyrite, quartz (vein and in inward-projecting crystals in dolomite eyes), dolomite (white)
Minor:	Limonite
Trace:	Microcline (orange-salmon), aragonite (sprays of needles on upper levels), calcite (white cleavages on late yellow sphalerite)

6. *Paragenesis:* Formation of collapse breccia; pyrite; gray sphalerite, dolomite and pyrite; fine-grained yellow sphalerite; tectonic brecciation; quartz and microcline; lemon-yellow sphalerite and dolomite; and calcite. There is probably more overlap than this oversimplified paragenesis suggests. The fine-grained yellow sphalerite is abundant only on the northwest edge of the orebody.

7. *Geologic Description:* The New Hartman orebody is one of the most economically important known metallic ore occurrences in the common-

2. Hemimorphite was definitely reported present in the unexamined upper levels.

wealth; it has recently been described by the former chief geologist of The New Jersey Zinc Company, W. H. Callahan (1968), and Metsger and others (1973). Unlike most of the other descriptions of Pennsylvania's zinc or lead occurrences, these descriptions are excellent. The present description will include only a summary of their reports and some recent observations.

The New Hartman orebody is located on the gently-dipping southeast side of an 18° southwesterly-plunging overturned anticline where bedding dips 25S. The mineable ore zone is usually about 60 to 75 feet (18 to 23 m) thick, but thicknesses of 150 feet (46 m) of ore yield an average of about 100 feet of presently mineable ore (30 m) (Metsger, 1973). Figure 5 of Callahan (1968) shows an ore-zone width of about 500 to 1500 feet (150 - 460 m). The described east-west extent of the lenticular orebody, i.e., from the Cemetery fault (if it exists) to the Old Hartman open pit, is about 1200 feet (365 m). The ore body extends downdip *on the order* of 6500 feet (2000 m) from the Old Hartman open pit based on shaft depth and ore plunge.[3] [Thus, even the deepened shaft would not permit mining within 2000 feet (600 m) of U. S. Route 309.] A *schematic generalization* of the orebody's probable shape is shown in Figure 32.

Along the footwall, the ore zone has been described by Metsger and others (1973, p. 4-5) as a "rubble breccia" of completely disrupted, rotated, and transported fragments derived from cave collapse in a paleokarst system (Figure 45). Nearer the hanging wall, it grades to a brickwork mortar or crackle breccia from slumping above the cave (or ore-solution-induced cavity): "As the ore is approached (from above) there is a gradually increasing bedding-plane separation with a concomitant rupture of individual beds. The 'mortar' in the resulting brickwork pattern is generally honey-colored sphalerite, pyrite, and dolomite in diverse proportions." Metsger further notes that all of the rock fragments within the rubble breccia have been derived from within the Beekmantown Group.[4]

In addition to the typical submetallic-gray sphalerite at Friedensville, a fine-grained, massive, yellow sphalerite occurs along the upper (up-dip limit), northwest side of the orebody. This yellow sphalerite has been observed by the author on the 21 west and 30 west stopes on the 1080 level. Trace amounts of red-brown sphalerite in coarse crystalline Allentown dolomite were found during excavation for the 1520 level pump station about 30 feet (9 m) off the shaft (A. H. Willman, personal commun., 1974). This would be about 120 feet (36 m) below the top of the Allentown Formation. Similarly, trace amounts of bright orange sphalerite have been

3. The 23-37 orebody of Callahan (1968) has been shown to be an integral part of the main orebody (Callahan, 1973).
4. A. V. Heyl (personal commun., 1976) takes strong exception to the present interpretation. Based on his personal observations, he interprets all of the breccias as being of tectonic origin, thus locating most of the ore in a thrust fault and northeast-trending veins extending upward from the thrust.

a. b. c.

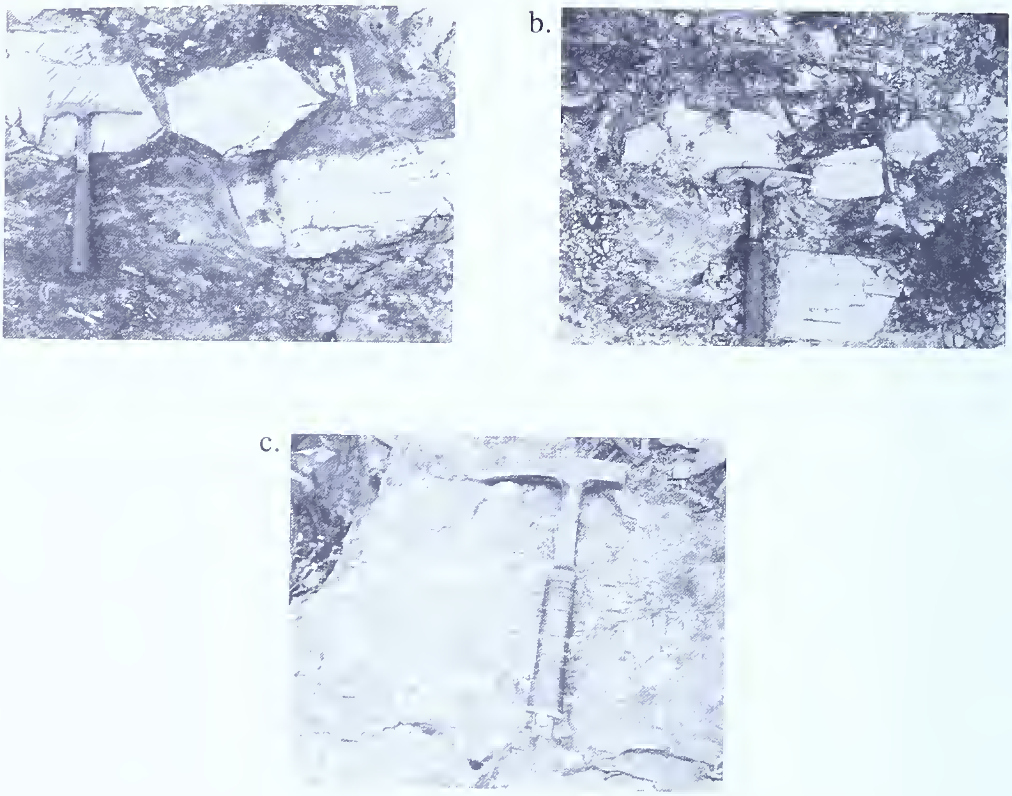


Figure 45. Sphalerite-bearing ore in rubble breccia, top of rib dividing Old Hartman open pit, Friedensville, Lehigh County. Note the apparent compaction around the large fragment with the lower right of a. and the rounded nature of the fragments in c.

found along late fractures above the assay hanging wall at the southeast end of 23 west stope on the 1170 level. These unusual colors of sphalerite, as well as scattered lemon-yellow sphalerite along late veins in the hanging wall, all suggest minor, tectonically induced remobilization.

Black chert was observed to be abundant below ore on the western side of the orebody and quartz-dolomite eyes in hanging wall ore.

As described by Metsger and others (1973), the main shaft is 20.5 × 13 feet (6.3 × 4 m) in cross section, and was completed to 1261 feet (384 m) in 1952. By 1974, the shaft had been extended to 2060 feet (628 m). Metsger described the incline as having a 15 × 15 foot (4.6 × 4.6 m) cross section and a 20% road grade (11° 20′). In the presently active portion of the mine, northwest stopes are cut on 72.5 foot (22 m) centers and 35 × 35-foot (11 × 11 m) pillars left for support. Presently, stopes trend N45W and are about 250 feet (75 m) long. Haulage levels were cut at 400, 600, 700, 800, 900, and 1050 feet (120, 185, 215, 240, 275, and 340 m). Below the 900 level, crosscuts from the incline are cut at 30-foot (9 m) levels.

Metsger and others (1973, p. 17) described mine and mill as follows:

> Mine and mill are equipped to handle 2,500 tons per day of crude

> ore. Lack of sufficient underground work force has curtailed production below capacity. At normal production of about 2,000 to 2,200 tons per day, grade of ore milled is 6.4 percent and the concentration ratio is ten to one.

As noted, perhaps facetiously, by Metsger and others (1973, p. 17), "Friedensville is probably the wettest mine in North America. Pump capacity is 31,000 gpm. All mining is below the water table, and careful test holing of ground in advance of mining is mandatory." Because of enormous pumping costs, the company has conducted extensive internal and consultant hydrology studies, but weathered zones in this karst area have been proven to 1,700 feet (520 m), and no simple solutions have been found. Disruption of the surface by sinkholes and iron ore mines (such as Greene's, Schneider's, Wint's, etc.) developed prior to zinc mining have complicated the problem.

Callahan (1968, p. 101, and 1973) reported that the Schneider iron mines area was drilled in search of zinc, but that no economic mineralization was found. Recent detailed geological mapping by A. A. Drake (U. S. Geological Survey, personal commun., 1973) and the stream sediment geochemical survey of Rose (1971) suggest that at least two additional nearby areas deserve exploration. The area of Applebutter Hill (about 3.25 miles = 5 km southwest of Friedensville and about 350 feet = 110 m high) deserves to be drilled to search for zinc in the south-dipping thrust of favorable Rickenbach Formation beneath the hill. Geochemical anomalies from the southeast side of Applebutter Hill suggest that Rickenbach may be present beneath the Triassic as well as Precambrian at a reasonable depth. The second area, around the south-dipping Colesville normal fault, (southeast of South Mountain) contains both mapped Rickenbach Formation and unexplained geochemical anomalies in the continuation of the same strata from the Ueberroth zinc mine. As national needs become critical, exploration of the Rickenbach Formation both beneath East Saucon Valley Road between Pa. Route 378 and the Northampton-Lehigh County line and 0.6 mile (1.0 km) northwest of Saucon Hill may become warranted. There also seems to be a reasonable chance that the abandoned limonite mines on the west edge of the Hellertown 7½-minute quadrangle are zinc gossans, and may some day be exploited. Tailings of 40,000 tons (36,000 metric tons) of 20% Zn (W. H. Callahan, 1973) from mining in the 1800's have been shipped to the Palmerton mill and the zinc has been recovered.

As noted by Callahan (1968), most of the ore is probably pre-deformation, but the area was probably deformed in the Taconic, Appalachian, and Triassic. As to the origin of the zinc, "We have learned nothing of the source at Friedensville" (W. H. Callahan, personal commun., 1973).

18. OLD HARTMAN MINE, LEHIGH COUNTY

(Former Large Zinc Producer With Probable Reserves)

1. *Name:* Old Hartman mine owned by The New Jersey Zinc Company.

2. *Location:* A. The Old Hartman open pit, divided by a northeast-southwest rib, is located 1700 feet (518 m) northwest of Friedensville (intersection of Old Bethlehem Pike and Saucon Valley Rd.) and 2750 feet (838 m) northeast of the operating New Hartman shaft. Truck access to the latter is through an incline from the south side of the southeast half of the Old Hartman open pit. The incline begins S4E of a bronze and lead survey marker in the rib dividing the open pits. The Old Hartman open pit is located about 1700 feet (518 m) southwest of the Ueberroth open pit. This area is in Upper Saucon Township, Lehigh County.

B. LATITUDE N: 40° 33′ 10″ LONGITUDE W: 75° 24′ 03″

C. TOPOGRAPHIC MAP: Allentown East $7\frac{1}{2}$-minute quadrangle.

3. *Host Rock:* Lower Ordovician Rickenbach Formation, a silty, medium-dark-gray, crystalline dolomite, which comprises the base of the Beekmantown Group. See Correll and Ueberroth mine reports for a more complete description. In addition to rubble breccias (Figure 45), massive dolomite, laminated dolomites, and clay-carbon enriched "shaly" dolomite are exposed in the open pit.

4. *Estimated Total Amounts of Ore Metals:*

A. <1 g:

1-1000 g:

1-1000 kg: Cd

>1000 kg: Zn (possibly, 50,000 tons of 2-6% ore could be recovered from the open pit)

Miller (1925a, p. 74) reports a district production of refined products as 50,000 tons of zinc spelter and 90,000 tons of zinc oxide (the latter equals 72,000 tons of zinc), and this is quoted by Callahan (1968). However, excluding large tonnages of sphalerite, the Ueberroth mine alone produced 300,000 tons of hemimorphite containing 35-40% zinc (Clerc, 1882). Ignoring large quantities of 10% sphalerite, considered "waste rock" in the 19th century, it seems likely that the district produced on the order of 800,000 tons of ore averaging 30% zinc by 1894. The author suspects that this would have been distributed very approximately as follows: Correll 100,000 tons ore, Old Hartman 200,000, Ueberroth 450,000, and Triangle 50,000.

From 1958 through 1975 the New Hartman ore body has produced a total of about 475,000 tons of zinc from 6% ore mined from the (20th century) New Hartman mine. The so-called New Hartman ore body was mined from all of the 19th century pits except the Ueberroth. Thus, the "Old Hartman ore body" is presently being mined through the 20th century New Hartman mine. There seems to be little value in renaming essentially one orebody, as it is mined down plunge from different shafts.

The displacement of the Nason fault between the New Hartman and Old Hartman mines is relatively minor.

B. ASSAYS: No published assays are available, but ore-grade (more than a few percent Zn) material is exposed a few places in the open pit. At the extreme west end of the NW pit there is several feet of 10% (visual estimate) Zn exposed in rubble-breccia footwall ore. The rib dividing the NW and SE pits contains 2-10% (visual estimates) Zn ore along much of its northeast half, especially on the top and northwest sides.

5. *Minerals Observed and Relative Amounts:*

A. ECONOMIC

Major:	Sphalerite (fine-grained, steel-blue-gray to yellow-gray)[1]
Minor:	Bianchite*
Trace:	Goslarite,* smithsonite

B. GANGUE

Major:	Pyrite (cubes), dolomite (coarse crystalline, white; rarely maroon)
Minor:	Quartz (as black chert and/or jasperoid)
Trace:	Quartz (milky), gypsum, ferrohexahydrite(?)*

6. *Paragenesis:* Solution of rock dolomite host, pyrite, gray tending to yellow sphalerite, white crystalline dolomite and minor pyrite. Butler (1935, p. 904) lists the general paragenesis for Friedensville ore as (1) pyrite, (2) sphalerite, and where deformation occurred, (3) pyrite and (4) recrystallized sphalerite may be present.

7. *Geologic Description:* The Old Hartman open pits are located on the crest of an overturned anticline plunging 18° southwesterly (Callahan, 1968, p. 101). Bedding on the south side of the pit trends N50W, 43S.

The sphalerite-bearing northwest face of the NW half of the Old Hartman open pit is a laminated dolomite which greatly resembles the north face of the Correll open pit. At the Old Hartman, the bedding(?) surface trends N81E and dips 56S. Slickensides on this surface trend N57W and plunge 50° to the southeast (Figure 46) vs. bedding of N78E, 47S and a slickenside trend of N55W at the Correll. Rich collapse breccia exposed at the extreme west end of the NW half further suggests that the Trihartco ore zone extends through the NW half. This is in minor conflict with Callahan's structural interpretation, and if correct, would locate an additional ore zone between the Ueberroth and Correll open pits. (See Figures 4 and 5 of Callahan for the relative locations of the open pits and structure.) The structure is probably more complicated than Callahan (1968) suggests. Miller (1924, p. 64) described both the bedding and veins at the Old Hartman mine as practically vertical.

The rib dividing the Old Hartman in half along a NE-SW axis contains considerable rock with 3-12% sphalerite, especially on the top and north-

1. Obviously, hemimorphite was present in immense tonnages prior to 19th century mining.

west sides. On the top of this rib are some fine outcrops of collapse breccia (Figure 45). Old yellow paint on this outcrop correctly portrays a N55W, 48SW cleavage. Unfortunately, bedding is indeterminate at this point. Surface outcrops in the SE half of the open pit are rather barren of sphalerite.

There is a N78E, 40° east-plunging cave-like opening into the northwest side of the rib. The host rock at the entrance is shaly from clay-carbon insoluble residue, but the rubble breccia contains some massive dolomite blocks. This opening may be obstructed within 20 feet (6 m) of the entrance. About 35 feet (11 m) southwest along the same rib there is a timbered, underground stope developed in moderately rich rubble breccia with abundant zinc, iron, calcium, magnesium sulfates on the face above the stope. Several underground stopes and drifts take off from the southwest end of the SE half of the Old Hartman, so ore must have been present at depth.

Clerc (1882) noted that the Old Hartman was first worked for hemimorphite and that this was pursued to a depth of 150 feet (46 m). Large bodies of sphalerite were found near the surface, and these were also pursued to depth. Figure 47 (Miller, 1924, p. 81) shows that both open "mines" were 90 feet (27 m) deep. Little is known about the Bull engine shaft shown on that figure. Clerc (1882, p. 363) reported that mining gradually developed a "horse" of sphalerite which had to be left for support of timbers for the underground workings. He reports a maximum depth of workings of 150 feet (46 m); and compared to the Ueberroth he observed that the Old Hartman veins were less steeply dipping, more nearly west dipping, the host rock less brecciated and that the sphalerite came closer to the surface.

Wild asparagus, sumac, horsetails and a peculiar variety of violets are especially abundant in the old slime basins on the west end of the NW half of the Old Hartman. Their growth may be promoted by the zinc-rich soils. A composite sample of scrubbed 100 one-inch (2.5 cm) chips of "limonite" lacking visible zinc minerals collected from this area was found to contain 1.6% Zn, 33 ppm Co, 23 Ni, 22 Cu, 400 As, 0.2 ppm Ag, and 55 ppm Pb.

Figure 46. Slickensides on insoluble-rich dolomite beneath collapse breccia sphalerite ore in the NW part of the Old Hartman open pit.

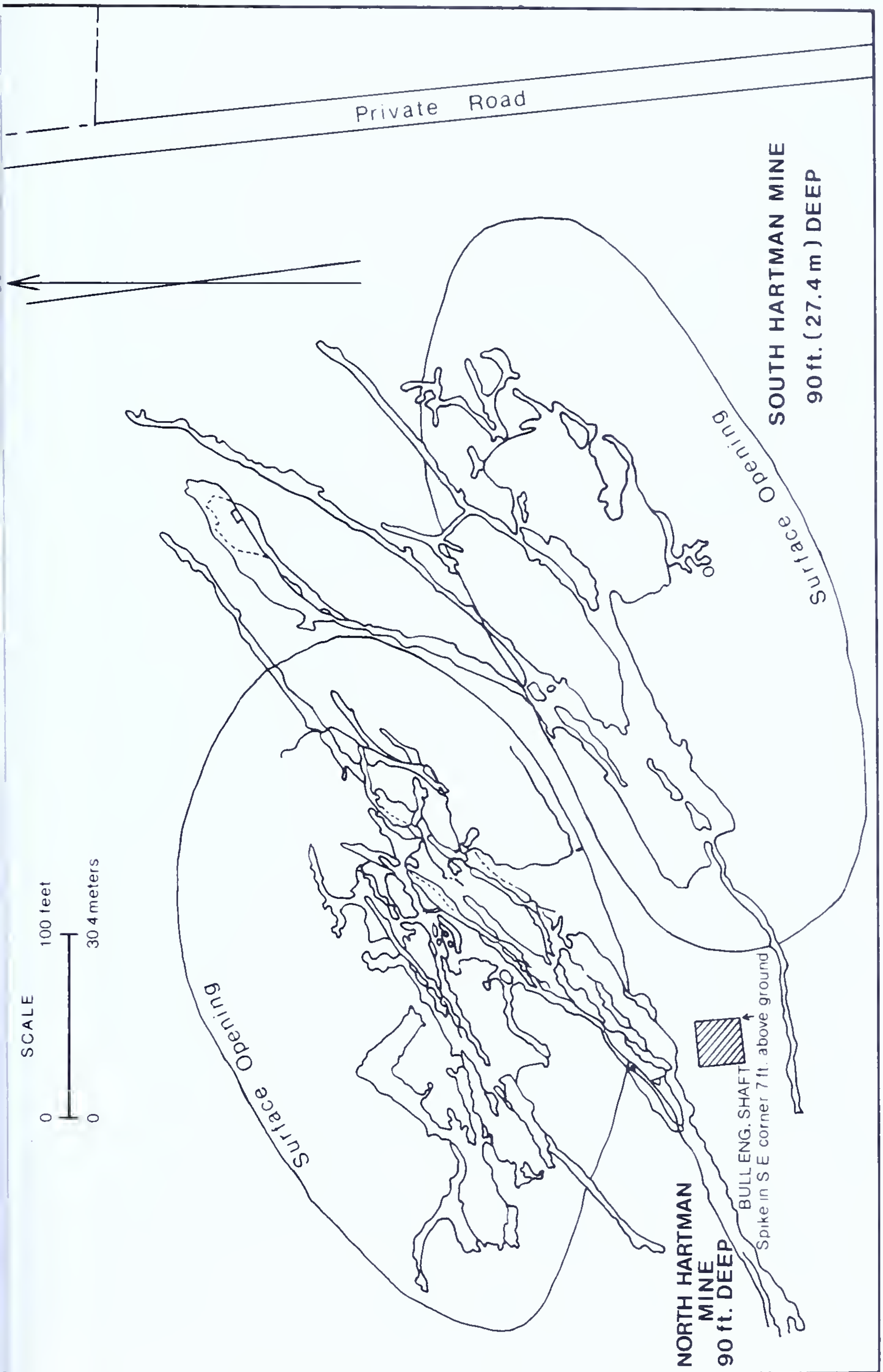


Figure 47. Distribution of sphalerite-bearing veins in Old Hartman mine, Friedensville, Lehigh Co. (Miller, 1924, and The New Jersey Zinc Co.).

19. OLEY VALLEY, BERKS COUNTY

(Major Zinc Occurrence)

1. *Name:* Oley Valley quarry is presently owned by Eastern Industries, Inc. of the Protection Services Corporation.

2. *Location:* A. The Eastern Industries Oley quarry is on the west side of Oley Valley, Oley Township, Berks County. This quarry is located 4500 feet (1375 m) north-northeast of Oley Line (Limekiln PO), 1.85 miles (2.95 km) southeast of Five Points, and 2.25 miles (3.55 km) southeast of Church Hill.

B. LATITUDE N: 40° 21′ 21″ LONGITUDE W: 75° 48′ 06″

C. TOPOGRAPHIC MAP: Birdsboro 7½-minute quadrangle.

3. *Host Rock:* Upper Ontelaunee Formation, probably of lower Chazyan, i.e., of Lower Middle Ordovician age (Hobson, 1963, and MacLachlan, 1967). The observed mineralization is in the top of the Ontelaunee, here composed of interbedded 1.5- to 3-foot- (.5 to 1 m) thick finely-crystalline medium-dark-gray dolomite and 1-foot- (0.3 m) thick micritic to microcrystalline medium-dark limestone. The interbedding may be cyclic upward from dolomite to limestone mottled with dolomite to limestone. The limestone weathers to a dark gray and the dolomite to a typical buff-light-gray. Stylolites are common, but chert is rare. M. G. Slenker, quarry geologist (personal commun., to B. J. O'Neill, 1976) reports trace sphalerite in the overlying Annville Formation in new exposures.

4. *Estimated Total Amounts of Ore Present:*

<1 g: U (as determined by gamma ray spectrometry)[1]
1-1000 g:
1-1000 kg: Cu
>1000 kg: Zn

5. *Minerals Observed and Relative Amounts:*

A. ECONOMIC

Major:	Sphalerite (tetrahedrons, often with etch or variable growth pits, with golden-yellow cores and thin black rims).
Minor:	
Trace:	Aurichalcite,* malachite, chalcopyrite(?)

B. GANGUE

Major:	Calcite (clear, colorless scalenohedrons up to 2 inches or 5 cm).
Minor:	Barite* (small white prisms), palygorskite,* pyrite, fluorite (purple cubes up to ⅛ inch or 3 mm. The color is concentrated in the outer zones, often as inky spots in nearly colorless fluorite. Because the bulk

1. Amount estimated to be concentrated in the fluorite samples collected.

samples of limestone with fluorite contain anomalous (30% over background counts) amounts of uranium, it is probable that the color centers are radiation induced).

Trace: Marcasite* (microcrystals in clear calcite).

6. *Paragenesis:* Tectonic(?) brecciation; hypogene sphalerite (yellow to black); barite; marcasite; fluorite; chalcopyrite; calcite; supergene malachite, aurichalcite.

Some pyrite and fluorite are included in the outer zones of the calcite crystals.

7. *Geologic Description:* The major structure in the Oley quarry is an anticline which trends about N60W and plunges northwest at 11°. The observed sphalerite is near the crest. The anticline is right side up, but is otherwise complex in the sense that the limbs are neither planar nor symmetric and the crest is faulted and folded. The most tangible evidence for this faulting is the tectonized inclusions of dark Jacksonburg limestone in the lighter-colored Ontelaunee dolomite. The anticline is crossed by a well-developed set of vertical joints trending N20 ± 2E. A few subvertical collapse breccias up to 5 to 8 feet (1.5 - 2.5 m) wide are probably developed on this joint direction. They are traceable across many beds in a vertical direction. Fragments in the collapse breccia are subangular and of variable lithology. Sphalerite was observed in only those collapse breccias which were also tectonically brecciated. Bedding near the sphalerite was N53W, 19SW, but the available bedding surfaces are of poor quality.

Hobson (1963) reports a thickness of 675 feet (205 m) for the Ontelaunee in central Berks County. Michael G. Slenker, geologist for Eastern Industries (personal commun., 1974) reports a thickness for the overlying Annville in the quarry area of 0 to 110 feet (0 - 34 m). The lowest 35 feet (11 m) of Annville is reported to contain about 95% $CaCO_3$. The thinnest observed Annville is on the fold crest where tectonic thickening rather than thinning is to be expected. Thinning by unconformity is probable. On the other hand, the Ontelaunee-Annville contact is gradational with absolutely no evidence for an unconformity. Gradation at the top of the Beekmantown Group does not rule out an unconformity at the top of the Annville where bedding in the Jacksonburg (or Myerstown Formation, but less likely because of the low $CaCO_3$ content) dips into the Annville. Thinning, however, does not prove an unconformity because tectonic decoupling across a limestone-shale contact is also probable. For the Lebanon Valley, D. B. MacLachlan (1967) places an unconformity of Black River age between the Annville and Myerstown (approximately equivalent to Jacksonburg) Formations, i.e., not directly on top of the Beekmantown Group.

The west end of the quarry is cut by a vertical, Rossville-type (Smith, 1973) Triassic(?) diabase dike containing euhedral anorthite phenocrysts. The dike is about 5 feet (1.5 m) thick and trends N18E. Contraction joints

perpendicular to the dike contacts are well developed. In the north face of the quarry, the dike has been faulted with the west side dropped down slightly. Fractures within the dike contain pyrite and calcite, but the dike appears to have had little thermal metamorphic or hydrothermal effect on the enclosing limestone.

Prior to learning of the occurrence of sphalerite in the Oley quarry, two composite limonite samples were collected from the area and analyzed for certain trace elements listed below in ppm:

Mine	Host	Latitude N Longitude W	Co	Ni	Cu	Zn	As	Ag	Pb
Weaver	Beekman- town?	40° 22′ 11″ 75° 47′ 09″	130	310	40	1900 (.19%)	25	<.1	40
Manwiller	Beekman- town	40° 21′ 26″ 75° 46′ 58″	210	450	70	3400 (.34%)	10	.1	50

The Weaver limonite sample contains only normal amounts of trace elements, whereas the Manwiller limonite is high in zinc and copper. It has the highest zinc content of eight composite limonites from the Cambro-Ordovician of Berks County; and for Pennsylvania, it has the third highest zinc content of any sampled limonite from a Cambro-Ordovician prospect without zinc production.

The observed amount of sphalerite is indeed minor and the uranium traces in the fluorite suggest an unusual type of occurrence. Against this one should consider: 1) The accepted post-Annville unconformity, 2) the interbedded limestone and dolomite suitable for extensive collapse breccia, 3) the observed, but unmineralized collapse breccia, 4) the presence of zinc as sphalerite and as a minor component of limonite in the area, 5) the occurrence in Beekmantown Group carbonates, and 6) the gross geologic similarity of Friedensburg area (Oley Valley) to the Friedensville area (Saucon Valley) zinc district.

During early 1976, Eastern Industries is reported to have taken the initiative to have the area prospected by a major base metal company. A drill hole, about 0.6 mile (1 km) northeast of the quarry is reported (M. G. Slenker, personal commun., 1976) to have collared in Martinsburg shale, penetrated "Jacksonburg" limestone at 90 feet (28 m), Annville limestone at 190 feet (58 m), the top of the Beekmantown Group at approximately 330 feet (100 m) and to have stayed in Beekmantown to a total depth of 2500 feet (760 m). No data are available on mineralization in either this core or in a second hole reported to have been drilled in the area mineralized with sphalerite.

The assistance of Michael G. Slenker, geologist for Eastern Industries, who kindly reported the occurrence to the Pennsylvania Survey, is gratefully acknowledged. Similarly, Samuel I. Root and David B. MacLachlan assisted with structural and stratigraphic interpretations.

20. ROARING SPRING AREA, BLAIR COUNTY

(Zinc Occurrences)

1. *Name:* (1) New Enterprise Stone and Lime Co., Inc. quarry at Roaring Spring, (2) roadcut along combined Pa. Routes 36 and 164, and (3) the E. Carper Limonite mine (named after the finder, Mr. E. G. Carper of Roaring Spring) owned by D. and John Matthews of Hollidaysburg.

2. *Location:* Each of these three zinc occurrences are on the north side of Roaring Spring, Taylor Township, Blair County.

Occurrence 1: The sphalerite-bearing bed in the New Enterprise quarry is best exposed in the northeast face of the quarry. This quarry is 0.85 mile (1.35 km) northwest of the junction of Pa. Routes 36 and 164 east of Roaring Spring, 0.3 mile (0.5 km) northeast of the junction of Pa. Route 867 with combined Routes 36 and 164, and 0.55 mile (0.9 km) southeast of the junction of Halter and Plum Creeks in McKee Gap.

Occurrence 2: The sphalerite-bearing bed in the roadcut of combined Pa. Routes 36 and 164 is best exposed on the south-southwest side of the cut 425 feet (130 m) east-southeast from the center of the east-turn lane of Pa. Route 867 onto combined 36 and 164. This point is 625 feet (190 m) west-northwest of the entrance of a private driveway onto combined 36 and 164 and 0.8 mile (1.25 km) south-southeast of the junction of Halter and Plum Creeks in McKee Gap.

Occurrence 3: The E. Carper limonite mine is located in a small grove of trees northeast of combined Routes 36 and 164, 0.25 mile (0.4 km) east-southeast from the junction with Pa. Route 867. This is north of the town of Roaring Spring and 0.85 mile (1.35 km) southeast of the junction of Halter and Plum Creeks in McKee Gap.

	New Enterprise Quarry at Roaring Spring (occurrence 1)	Pa. Routes 36 and 164 (occurrence 2)	E. Carper Limonite mine (occurrence 3)
B. LATITUDE N	40° 23′ 47″	40° 20′ 28″	40° 20′ 28″
LONGITUDE W	78° 23′ 56″	78° 24′ 08″	78° 23′ 57″

C. TOPOGRAPHIC MAP: Roaring Spring $7\frac{1}{2}$-minute quadrangle.

3. *Host Rock:* The sphalerite-bearing bed (36 inches or 92 cm thick) in the New Enterprise quarry at Roaring Spring (occurrence 1) is in the Bellefonte Formation 675 ± 25 feet (205 ± 8 m) beneath the lowest limestone bed of the Milroy Member of the Loysburg Formation.

The sphalerite-bearing beds in the roadcut of Pa. Routes 36 and 164 (occurrence 2) are in the Bellefonte Formation 600 ± 50 feet (185 ± 15 m) beneath the lowest dolomitic limestone bed of the top of the Bellefonte Formation. The stratigraphically higher limestone beds north of the junction of Pa. Route 867 with combined Routes 36 and 164 have been removed by quarrying.

The E. Carper limonite mine (occurrence 3) is mapped as being in upper Axemann Formation (Butts, 1945). The outcrops in the pit, however, are light-gray, fine-grained dolomite typical of the Bellefonte Formation, as are the large, gray, concentrically-banded chert nodules found as float in the pit. Therefore, the mine probably is in the base of the Bellefonte Formation or at an Axemann Formation horizon where Bellefonte dolomite lithology prevails instead of the fossiliferous limestone of the Axemann. Thickening of the Bellefonte at the expense of the Axemann has been noted about 1 mile (1.6 km) south-southwest of Roaring Spring (Butts, 1945) and elsewhere (Lees, 1967).

4. *Estimated Total Amounts of Ore Metals:*

	New Enterprise Quarry at Roaring Spring (occurrence 1)	Pa. Routes 36 and 164 (occurrence 2)	E. Carper Limonite mine (occurrence 3)
A.			
<1 g:			
1-1000 g:			
1-1000 kg:		Zn^1 (5×10^2 kg)	
>1000 kg:	Zn^2 (1.5×10^5 kg)		Zn^3 (3×10^4 kg), Pb (2.5×10^3 kg)

B. ASSAYS (in ppm):

	Co	Ni	Cu	Zn	As	Ag	Pb[4]
Limonite from E. Carper mine (53 one-inch chips)	5	60	25	7,500	20	0.2	530

5. *Minerals Observed and Relative Amounts:*

A. ECONOMIC

	New Enterprise Quarry at Roaring Spring (occurrence 1)	Pa. Routes 36 and 164 (occurrence 2)	E. Carper Limonite mine (occurrence 3)
Major:	Sphalerite (orange-brown)		Limonite (some mm-sized pseudomorphs after pyrite)

1. Based on the assumption that trace sphalerite (0.05% Zn) continued 25 feet (8 m) in both directions along strike.
2. Based on the assumption that the 36-inch (92 cm) wide sphalerite-bearing bed traced across the quarry contains 0.5% Zn.
3. Based on the estimate that the pit contained 50% limonite assaying 0.75% Zn and 0.05% Pb over a volume of $200 \times 20 \times 25$ feet ($60 \times 6 \times 8$ m).
4. Since sampling, the pit has become a rifle target range. Prior periods of target shooting, if any, could possibly account for higher than normal lead in the surface limonites. The low copper content suggests that brass shell casings have not contributed appreciably to the zinc content.

Minor:		Sphalerite[5] (mostly bright, lemon-yellow, but also colorless and gray-brown)	
Trace:			
B. GANGUE			
Major:	Quartz (jasperoid and crystalline)	Quartz (in crystalline rosettes and chert)	
Minor:	Fluorite (purple cubes), celestine* (white and blue) and dolomite (white crystals and coarse cleavable masses), baryto-celestine*	Dolomite (white and pale blue* eyes)	Quartz
Trace:	Pyrite, strontianite	Pyrite (in clay-carbon-rich areas), calcite (clear, colorless films on fractures)	

6. *Paragenesis:* For the siliceous bed at New Enterprise's quarry (occurrence 1) at Roaring Spring: dolomite rock; silica as dark jasperoid; silica as light-gray jasperoid and agate; orange-brown sphalerite, rare pyrite, and thin films of agate; quartz crystals in vugs; sparse white dolomite crystals.

For the rare sphalerite eyes outside of the siliceous bed at New Enterprise's Roaring Spring quarry: deposition of dark-gray dolomite rock; quartz eye development by replacement (quartz includes black clay-carbon and is partially rimmed by pyrite); bright-lemon-yellow sphalerite and white dolomite in center of quartz eye; deformation resulting in slickensides on clay-carbon accumulations; white, vein dolomite filling fractures cutting all minerals.

Although not spatially related to sphalerite, the blue celestine (celestite) crystals at the quarry occur on white to pale-blue(?) nailhead calcite crys-

5. Some of the sphalerite occurring in dolomite is brilliantly fluorescent under ultraviolet light.

tals. The strontianite is a secondary (supergene) mineral forming on the weathered celestine.

For the Pa. Routes 36 and 164 combined locality (occurrence 2): deposition of dark-gray dolomite rock; black and light-gray chert; quartz rosette formation; trace pyrite; yellow sphalerite in light-gray chert, quartz rosettes, and near clay-carbon accumulations, gray-brown sphalerite in black chert; white and pale-blue dolomite in veins and light-gray chert. It is uncertain if all colors of sphalerite are approximately contemporaneous as implied above.

For the E. Carper limonite mine (occurrence 3), it is known only that at least much of the limonite has altered from pyrite.

7. *Geologic Description:* These three occurrences of zinc in dolomite of the Bellefonte Formation occur on the vertical to slightly overturned west or northwest limb of the Roaring Spring anticline near where the Bellefonte plunges northward beneath the surface. The Baker Summit thrust fault disappears to the south of Roaring Spring and no other major faults are known in the area (Butts, 1945). A minor fault appears to occur on the east side of the Roaring Spring quarry. The mineralization in the E. Carper mine could be controlled by such a fault and indeed, there is some dolomite breccia float in the mine, but it is of unknown origin. There are a few wedge faults exposed along the north face of the Roaring Spring quarry, but none appears related to zinc mineralization.

The sphalerite in the quarry (occurrence 1) and the roadcut (occurrence 2) are at a similar, and possibly the same, stratigraphic level where bedding is N26E, vertical and N25E, 85W, respectively. The sphalerite-bearing bed exposed in the north wall of the quarry (occurrence 1) is 36 inches (93 cm) wide and can be traced about 1200 feet (0.35 km) to the south wall where it has the same general character. This dolomite bed has been partly replaced by silica as both jasperoid and quartz. An 8-10 inch (20-26 cm) zone of barren dolomite has been left within the bed. The rock on either side of this 36-inch siliceous bed is medium- to dark-gray micritic dolomite.

The sphalerite in the roadcut (occurrence 2) is in fine-grained dark-gray (N3) laminated dolomite. The sphalerite here occurs in large, light-gray chert nodules; quartz and white dolomite rosettes, and with clay-carbon accumulations in shaly laminae between beds. The typical Bellefonte dolomite in the rest of the roadcut is fine-grained, medium-gray, generally laminated dolomite in beds from 1-10 feet (30 cm to 3 m) thick with white to black chert. The white cherts are oblate and commonly exhibit a vague concentric banding. The black cherts are flattened along bedding. The contacts between beds are often undulatory with evidence of scour or solution. Dark shaly pyritic laminae are common between beds.

The sphalerite occurrences in Bellefonte Formation in the quarry and roadcut are similar to sphalerite observed in clots (0.5 to 3 cm "eyes") and cherts in the upper half of the Bellefonte Formation elsewhere in

Morrison Cove and the northeast end of Sinking Valley. In places, veins of gangue minerals penetrate the quartz-dolomite-sphalerite rosettes, suggesting that the rosettes formed prior to the Appalachian Orogeny.

The E. Carper mine (occurrence 3) is nearer the plunging crest of the anticline where bedding is N55E, 51NW. The dolomite outcrops in the sides of the E. Carper mine are fine grained and light gray.

Analyses for a series of soil samples collected at 100-foot (31 m) intervals on a traverse trending N80W (Plate 3) are summarized below. The sampling procedure is the same as that used at the Soister mine (Smith, 1974).

Station	Location	Zn ppm	Pb ppm
E312	John Matthews-Leana Ayers property line N12W of Ayers house.	No sample	
E300		75	40
E200		69	35
E100		95	35
00	Sour cherry tree 475 feet (147 m) along John Matthews farm driveway north of centerline of Pa. Routes 36 and 164.	82	37
W100		115	29
W200		135	28
W300	27 feet (8 m) north of upper rim of E. Carper mine.	69	30
W400		46	27
W500	Approx. on strike with E end of cut on highway.	62	45
W600		77	44
W700	West edge of Matthews field.	64	30
W755	Center of gravel road bearing N20E.	No sample	
W800	Middle of small dump mounds.	No sample	
W820	Crest of clay-dolomite artificial ridge.	No sample	
W850		130	42
W900		78	33
W1000	Bellefonte dolomite dumps. Cairn.	155	30
W1100		180	52
W1200		62	36
W1300		85	53
W1400		115	37
W1500		84	41
	Cliff on north projection of Pa. Route 868 and N25E of Appleton Paper Company stack.		

The slightly anomalous zinc values at W1000 and W1100 tend to confirm

the continuation of the siliceous, sphalerite-bearing zone in the Bellefonte Formation and suggests that it is probably narrow and of low grade.

Stream sediment geochemical data were obtained from selected sites in Roaring Spring, Martinsburg, and Hopewell $7\frac{1}{2}$-minute quadrangles to test for additional occurrences between the Roaring Spring, Woodbury, and Soister prospects. The results, largely negative, are presented on Plate 3, showing the drainage distribution and metal contents of the sediments. The general area between Martinsburg and Curryville may deserve a limited investigation because of the favorable lithology and slightly high zinc values in the sediments. Because of the probability of subsurface drainage in this area, some cross-strike soil sample traverses are suggested. Proximity to urban areas is unfavorable to the other apparent anomalies both from the possibility of a spurious anomaly source (i.e., pollution) and the difficulty in evaluating anomalies from natural processes.

21. SOISTER LIMONITE MINE, BLAIR COUNTY

(Iron Ore, Rich In Zinc)

1. *Name:* The area of the Soister (limonite) Mine is owned by Dan Kensinger. The farm less than 150 feet (45 m) north of the mine is owned by Ira and Bertha Stern. The farm east of the Soister Mine is owned by J. and V. Mellott (see Plate 3).

2. *Location:* A. The location of the Soister mine is today marked by one maple and one double-trunked oak tree near a clay mound in a field about 250 feet (75 m) southwest of the paved edge of Pa. Route 36 and 130 feet (40 m) southeast of Dan Kensinger — Ira and Bertha Sterns' property line. This area is 1.35 miles (2.15 km) southeast of Ore Hill, 2.25 miles (3.6 km) west-northwest of Curryville, and 3.5 miles south-southeast along Pa. Route 36 from its intersection with Pa. Route 164 in Roaring Springs. The Soister mine is in Taylor Township, Blair County, 0.5 mile (0.85 km) northeast of the Bedford County line.

	Soister Mine and Soister Limonite I and II Area	Soister III Limonite Area	Mellott Sink Hole
B. LATITUDE N:	40° 17′ 13″	40° 17′ 08″	40° 17′ 04″
LONGITUDE W:	78° 22′ 42″	78° 22′ 46″	78° 22′ 09″

C. TOPOGRAPHIC MAP: Roaring Spring $7\frac{1}{2}$-minute quadrangle.

3. *Host Rock:* Based on the map of Butts (1945), the Soister mine is in the Nittany Formation of the Beekmantown Group. Using Butts' contacts and bedding data, the Soister mine is about 375 feet (115 m) below the base of the Axemann Formation. The collapse breccia in the Mellott sink hole would be similarly calculated to be in the Axemann Formation. Spelman (1966) measured a thickness of about 1,280 feet (395 m) for the Nittany

at the Waterside measured section, 5.25 miles (8.5 km) due south of the Soister mine. This is in good agreement with a thickness of about 1350 feet (415 m) calculated from the dip and outcrop width of Butts (1945) for the mine area. Butts (1945) and Lees (1967) agree that the Axemann ranges from 0 (missing) to 200 feet (62 m) thick in this area.

4. *Estimated Total Amounts of Ore Metals:*

A. <1 g:

1-1000 g:

1-1000 kg:

>1000 kg: Zn (probably more than 2.5×10^6 kg, or 2750 tons[1])

B. ASSAYS (in ppm except as noted):

	Co	Ni	Cu	Zn	As	Ag	Pb	Sample Size
Soister I	15	60	15	1.6%	820	.1	100	57 one-inch chips
Soister II	90	45	15	1.45%	850	.1	150	82 one-inch chips
Soister III	300	120	20	750	610	.1	60	75 one-inch chips
Clay Mound				0.58%			32 subsamples of soil over 200 feet (60 m).	

Soister I was limonite collected from the immediate mine area by Mr. E. G. Carper, who also assisted in relocation of the mine. Soister II was limonite collected by the author from the mine area and about 150 feet (45 m) around it. Soister III was limonite collected from a depression about 600 feet (185 m) S33W of the Soister mine. The Clay Mound soil sample was collected from a ½ to 2-inch (1 to 5 m) depth on a traverse 25 to 225 feet (8 to 68 m) from the double-trunked oak tree toward Dan Kensinger's silo.

5. *Minerals Observed and Relative Amounts:*

A. ECONOMIC

Major: "Limonite" (containing about 1.5% Zn)[2]

Minor:

Trace:

B. GANGUE

Major: Quartz (clear, millimeter-sized crystals in the Soister I and II limonite samples and as loose, single crystals

1. Based on Platt (1881), the western Soister mine was 100 feet long by 60 feet wide and 20 feet deep (30 by 18 by 6 m). A 30-foot- (9 m) deep shaft from the bottom of the pit proved ore for an additional depth of more than 30 feet, yielding a probable "ore body" of $100 \times 60 \times 50$ feet, or 3×10^5 cubic feet. This "ore" would weigh about 5.4×10^5 lb. or 2.7×10^5 tons. If the "ore" consisted of equal amounts of clay containing 0.6% Zn and limonite containing 1.5% Zn, it would contain 2.8×10^3 tons of Zn worth 2.2×10^6 dollars based on Feb. 1974 prices (about $0.40/pound). Presently, zinc cannot be economically recovered from this grade limonite, but the calculations do show an enticing concentration of zinc. The sulfurous ore reported at depth (Platt, 1881) could be richer than 1.5% Zn.
2. The author looked for, but did not observe, hemimorphite or smithsonite.

in soil from the fields southwest of the mine), "chert" (various types including a gray bedded variety which must be silicified limestone or dolomite), and pyrite (Platt 1881, p. 201, reported ". . . great masses of decomposing iron pyrites were taken from the shaft, . . .")

Minor:

Trace:

6. *Paragenesis:* Unknown because no fresh sulfide samples were obtained. Based on Platt's description, the limonite is an oxidation product of pyrite. Some of the chert is apparently silicified dolomite or limestone, commonly termed jasperoid.

7. *Geologic Description:* The Soister mine is located on the gently dipping eastern limb of the Roaring Spring anticline. There are no outcrops in the immediate vicinity of the Soister mine, but Butts (1945) measured dips of 15° and 16° along strike, and the author found that Axemann Formation 0.6 mile (1 km) southeast of the mine dipped 16° to the east-northeast. The western limb of the Roaring Spring anticline is steeply dipping to overturned and is truncated by the Baker Summit fault, known in places to be a shallowly eastward-dipping thrust fault.

Because Butts (1945) found no faults in the Soister mine area, and because no tectonic breccias were observed by the author, the localization of zinc probably cannot be ascribed to structure as at the Woodbury area 4.5 to 5.75 miles (7 to 9 km) southwest of the Soister mine. Also, the ore does not appear to have washed in from the Ore Hill limonite mines in the Gatesburg Formation 1.4 miles (2.2 km) west of the Soister mine. Instead, it appears that zinc may have been localized in a collapse-rubble breccia. Platt (1881, p. 201), for example, furnishes a description of what could be a highly-weathered, siliceous, pyritic collapse breccia:

> The ore lumps are usually not rounded; there are many rounded pieces of flint and limestone and occasional masses of flint and limestone pieces cemented by a matrix of iron ore. . . . The ore was rich in iron, but extremely sulphurous; in fact, great masses of decomposing iron pyrites were taken from the shaft, pyrite making the inside of the mass and a hematite crust surrounding it.

In the vicinity of a large sinkhole on the Mellott farm, 0.5 mile (0.8 km) east of the Soister mine, there are very large masses of collapse breccia(?) with insoluble residue accumulation in the matrix. These are reported to have been recently excavated from the foundations for two new houses a few hundred feet to the northwest and south of the sinkhole. This would place the source of the solution breccia in the Axemann Formation, a fossiliferous limestone with minor, interbedded dolomites. This breccia consists of dolomite and minor gray chert and white quartz fragments in matrix of black, silty, insoluble residue.

In his discussion of the Soister Mine, Platt (1881, p. 200-201) indicates that there was

> a small one (pit) on the east side of the road, [presumably Pa. Route 36]. . .only about 10 feet deep; and numerous shallow trial pits put down near the open pit have found ore in clay. The outcrop of ore [iron] and ore-clay is decided, but neither so extended in area, nor so rich, as on the west side of the road. One of these trial pits was 80 feet deep, and never, in that whole distance, struck any solid rock. The ore in general appearance is exactly the same as that showing at the western pits.
>
> The [iron] ore outcrop is heaviest just around these Soister mines; but it continues to color the soil for some distance beyond, and on the Gartland place, one mile to the north-northeast from the Soister mines, good iron ore has been gathered from the surface in the fields, but no trial pits [were] ever put down.

Neither the east Soister pit nor the Gartland place limonite occurrence has been relocated.

According to Chafetz (1969), there is no unconformity at the top of the Beekmantown Group in central Pennsylvania which could account for the collapse breccias in the manner proposed in east Tennessee (Hoagland, 1971). Nevertheless, the author has observed collapse rubble breccia at five locations in Morrison's Cove. The Bellefonte Formation is gradational into the overlying Milroy Member of the Loysburg Formation along Pa. Route 869 east of New Enterprise, in the New Enterprise quarry at Roaring Spring, along Pa. Route 164 at Clover Creek, along Pa. Route 350 just southeast of the Blair-Huntingdon County line, and at several sections described by Chafetz. It is speculated that either a regional unconformity is present higher in the Chazyan or even Black River, or that the observed collapse breccias are the result of local unconformities developed in a supratidal environment, or that they are developed by the largely spent hydrothermal solutions which deposited the pyrite. It would seem difficult, however, to account for collapse breccias on the order of 2000 feet below the top of the Beekmantown formed beneath a local supratidal zone.

Eleven occurrences of sphalerite have been found in the Beekmantown Group within 8 miles (13 km) of the Soister mine. These other occurrences, however, appear to be disseminated in siliceous zones in the Bellefonte Formation or in fault breccias in the Nittany Formation. It is likely that there is at least as much zinc in this part of Morrison's Cove as in Sinking Valley, 22 miles (35 km) to the north-northeast. Galena and barite veins, however, are much less common in the Cove.

"Plough" soil samples were collected across the north end of the Kensinger farm just southeast of a N40E trending tree row marking the boundary with I. and B. Sterns' farm. No significant areas of soil anomalously high in zinc were found here, but the clay mound sample contains 0.58% Zn and suggests the use of B-zone soil traverses.

Sample Number-Location[3]	Comments	Zn ppm
00	SW edge of Kensinger field and 25 feet (8 m) SE of property line	90
100		75
200		85
300		90
400		95
500		105
600	Soil orange-red, Fe-rich and crops poor	155
700	0 + 730 is NW of Soister III limonite	125
800		115
900		130
1000		125
1100		115
1200		125
1300	0 + 1325 is NW of Soister mine and II and III limonites	105
1400		165
1500	0 + 1584 is centerline of Pa. Route 36	175
1620	From 0 + 1620 to 0 + 1815 the soil is very cherty	120
1700		80
1800		75
Clay mound	Collected 25 to 225 feet (8 - 70 m) south-southeast of the tree used, somewhat arbitrarily, to define the Soister mine location.	.58%
II A zone	Collected on a 10-foot (3 m) radius around the same tree.	355

3. The location numbers are also footages along a traverse, the ends of which are located on Plate 3. Sampling details are given by Smith (1974).

22. SOUTHERN SINKING VALLEY INCLUDING ALBRIGHT FARM OCCURRENCE AREA, BLAIR COUNTY

(Former, Very Small Lead Producers And Prospects)

1. *Name:* A. Albright occurrence owned by Ernest and Phyllis Albright. This is occurrence No. 2 of Zeller (1949), number 7 of Reed (1949a), and the Tatham farm of Platt (1881, p. 270-271). See Figure 48, an old property map of southern Sinking Valley (Nichols, 1873) and Figure 49, a portion of the Bellwood 7½-minute quadrangle.

B. J. G. Fleck (Platt, 1881, p. 268-270) occurrences owned by Earl and Sue Albright. This is occurrence No. 4 of Zeller (1949), number 2 of Reed (1949a), and according to a historical marker (Figure 50), the site of Revo-

Figure 48. Property ownership map of southern Sinking Valley as of 1873 by Beach Nichols. This serves as the basis of the present nomenclature system and was used to evaluate earlier reports.

lutionary War mining, which may, however, have been more widespread in southern Sinking Valley.

C. Keystone Zinc Company's "Deep Shaft" owned by Fred A. Good. Based on the map of Platt (Morrison Cove sheet 2, 1881), Zeller (1949) and Reed (1949a) associated this description with the wrong locations. This is on the Borie farm of Platt (1881). Platt (p. 269) reported another occurrence between the "Deep Shaft" and the Fleck house.

D. B. W. Bridenbaugh occurrences (Platt, p. 81, 265) owned by Fred A. Good. This is the correctly located occurrence No. 3 of Zeller (1949) and the incorrectly located occurrence No. 4 of Reed (1949a).

E. D. Ramey occurrences (Platt, 1881, p. 265-266) owned by Real Farms, Inc. of Fred Del Grosso. This occurrence was not located by Zeller (1949) and is the incorrectly located number 5 of Reed (1949a).

F. Crissman occurrences (Platt, 1881, p. 266-267) owned by Robert S. Black. This is number 8 and part of incorrectly located number 7 of Zeller (1949) and number 3 of Reed (1949a).

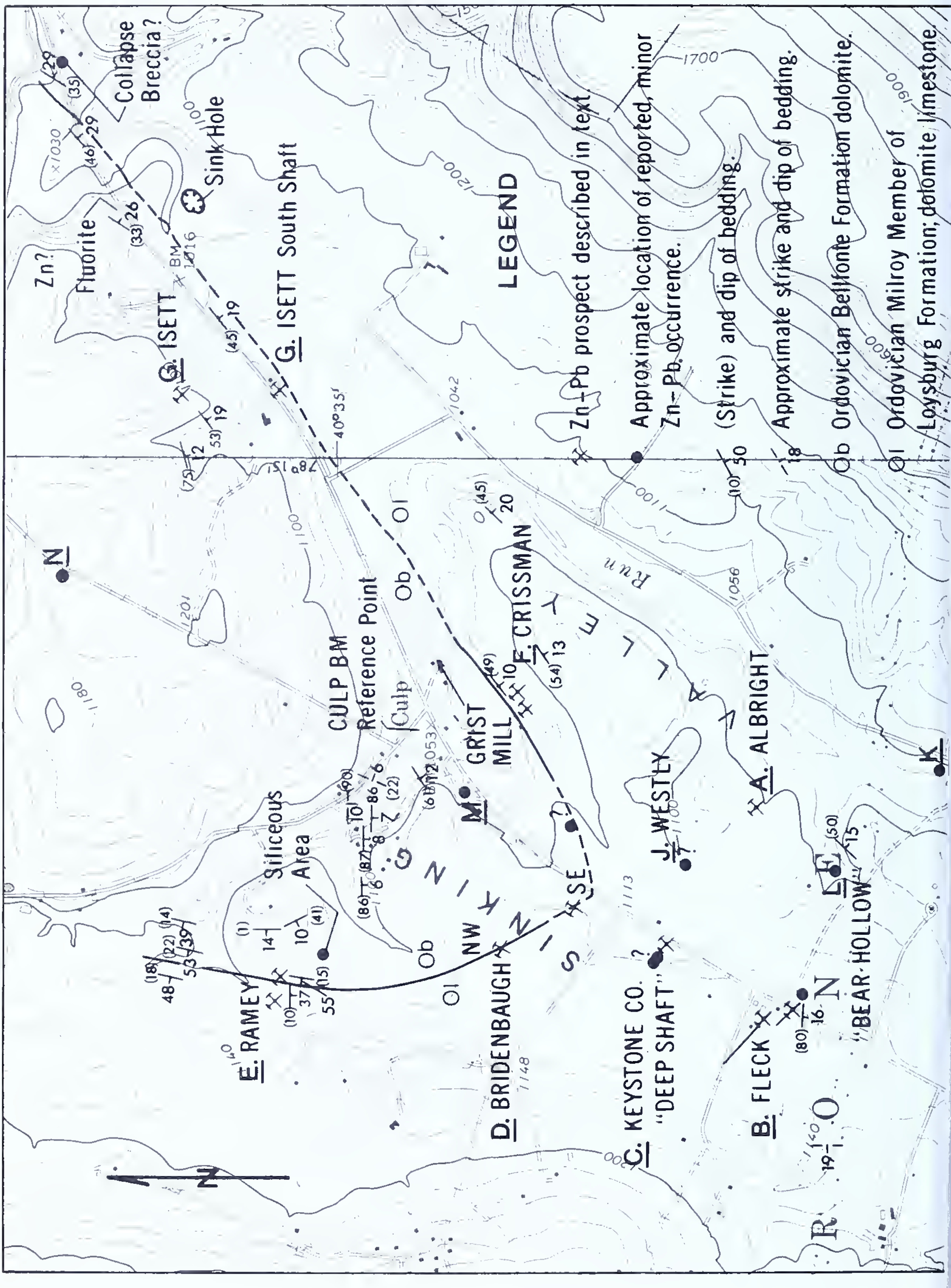

LEGEND
Zn–Pb prospect described in text.
Approximate location of reported, minor Zn–Pb occurrence.
(Strike) and dip of bedding.
Approximate strike and dip of bedding.
Ob Ordovician Bellefonte Formation dolomite.
Ol Ordovician Milroy Member of Loysburg Formation; dolomite, limestone.
A. ALBRIGHT
B. FLECK
C. KEYSTONE CO. "DEEP SHAFT"
D. BRIDENBAUGH
E. RAMEY
F. CRISSMAN
G. ISETT
G. ISETT South Shaft
J. WESTLY
"BEAR HOLLOW"
GRIST MILL
CULP BM Reference Point
Culp
Siliceous Area
Collapse Breccia?
Sink Hole
Fluorite
Zn?
SINKING VALLEY
Run
NW
SE
N
K
M
R. O N

Figure 50. Historical marker locating the site of Revolutionary War lead mining at the old Fleck prospect, southern Sinking Valley, Blair County.

G. Mary Isett occurrences (Platt, 1881, p. 271) owned by Marl and Quinlan Fisher, Jr. Prior to Mary Isett, the property was owned by Granville John Penn who somehow obtained it from the Indians. These prospects are the incorrectly located number 7 of Reed (1949a) and unmentioned by Zeller (1949).

In addition to the above which were located during the present study, Platt (1881) mentions the following:

H. McMullen occurrences (p. 264-265),
I. Jacob Kryder occurrences (p. 265), and
J. the Westley occurrences (p. 267-268).

Zeller (1949) also mentions:

K. the Ernst Albright milkhouse (Zeller number 5, p. 51),
L. "Bear Hollow" (Zeller number 6, p. 51), and
M. Roller Fleck milkhouse (Zeller number 7, p. 52) occurrences.
N. Post-hole occurrences owned by Stanley Crawford.

2. *Location:* A. — Occurrences A through F are in the southern part of Sinking Valley, Tyrone Township, Blair County.

A. The Albright mine occurrences are located 3500 feet (1100 m) south-southwest of the 1053-foot bench mark at Culp, 8500 feet (2600 m) northeast of the 1241-foot bench mark at Sickles Corner, and about 1700 feet (515 m) southeast of the Kettle to Culp township road.

B. The Fleck occurrences are located about 4800 feet (1475 m) southwest of the Culp B.M., 7100 feet (2175 m) northeast of the Sickles B.M., and about 250 feet (76 m) northwest of the township road. As a result of restricted property entry, the data of Zeller (1949) have been used throughout this report. The south Fleck occurrence was found at a historical marker on the northwest side of the road 5100 feet (1550 m) southeast of the Culp B.M. and 6800 feet (2100 m) northeast of the Sickles Corner B.M.

C. The Keystone Company "Deep Shaft" is located 3500 feet (1150 m) southwest of the Culp B.M., 8500 feet (2600 m) northeast of the Sickles B.M., and just northwest of the township road. Platt (1881, p. 267) reported the Westley pit 800 feet (240 m) to the east and the Morrison Cove sheet shows a shaft 900 feet (280 m) S80E of the "Deep Shaft."

D. The Bridenbaugh occurrence consists of a concentration of mineralization (old shafts?) at two distinct areas. The southeast area is located 2500 feet (750 m) southeast of the Culp B.M., 9500 feet (290 m) northeast of the Sickles B.M., and 300 feet (91 m) northwest of the township road. The northwest area is 2500 feet (760 m) west-southwest of Culp, 10,000 feet (3000 m) northeast of the Sickles B.M., and 1100 feet (340 m) northwest of the township road.

E. The Ramey occurrence consists of sparse mineralization in an outcrop and an apparent shaft site on the hillside of the east-southeast. The shaft site is located on the west side of a knoll, 3150 feet (975 m) northwest of the Culp B.M., 6400 feet (1950 m) southwest of St. Johns Church, and at an elevation of 1130 feet (345 m). The outcrop is located about 300 feet (90 m) west-northwest of the shaft site at the non-existant intermittant drainage which is shown on the Bellwood $7\frac{1}{2}$-minute topographic map. The outcrop is 3450 feet (1050 m) northwest of the Culp B.M., 6650 feet (2000 m) southwest of St. John's Church, and at an elevation of about 1110 feet (338 m).

F. The Crissman occurrence consists of the remains of two pits. The east-northeast pit is more pronounced and is located 1000 feet (300 m) south-southeast of the Culp B.M., 6400 feet (1975 m) southwest of St. Johns Church, and at an elevation of 1070 feet (326 m). The less conspicuous pit is about 225 feet (69 m) S85W of the more pronounced pit.

G. The Mary Isett south shaft is located 4000 feet (1200 m) northeast of the Culp B.M. and 3450 feet (1075 m) south-southeast of St. Johns Church, on the southeast side of the Culp-Arch Spring road, at REA Co-Op pole number 10-N-89. The Mary Isett north shaft is located at an elevation of 1110 feet (338 m) at a point 4500 feet (1380 m) northeast of the Culp B.M. and 2400 feet (740 m) south-southeast of St. Johns Church. Distance from the south to the north shafts is 1050 feet (320 m) due north.

The following occurrences were not located:

H. The McMullen occurrence was located by Zeller (1949) as ". . . 0.28 mile on the bearing S20E from the road intersection at Scalp Level," (intersection elevation 1181 feet or 338 m). This agrees with an iron ore location on the map of Nichols (1873) and the correct location may be closer to the Reedsville Formation contact.

I. The Jacob *Kryder* occurrence was described by Platt (1881, p. 265) as between the house, barn, and fields southwest of the house. Nichols' map (1873) locates the J. C. *Cryder* farm about 700 feet (215 m) southwest of the Skelp intersection and 4100 feet (1250 m) east-southeast of the 1642-feet- (500 m) high gap in Brush Mountain.

J. See C, above.

K. The Ernst Albright milkhouse is probably near the barn shown on the Bellwood $7\frac{1}{2}$-minute topographic map 5700 feet (1750 m) south of the Culp B.M. and 7300 feet (2200 m) northeast of the Sickles B.M.

L. The "Bear Hollow" occurrence is probably beneath the trash dump on the southwest side of the hollow 4800 feet (1475 m) south-southwest of the Culp B.M. and 7400 feet (2225 m) northeast of the Sickles B.M.

M. The Roller Fleck milkhouse occurrence is probably about 800 feet (245 m) southwest of the Culp B.M. and 1300 feet (400 m) northeast of the Sickles Corner B.M.

N. The post hole occurrence was reported by Stanley Crawford (personal commun., 1973) as 6 to 8 feet (1.8 to 2.2 m) southwest of a hickory tree on the northwest side of a secondary road between Culp and St. Johns Church. This is 4400 feet (1350 m) northeast of the Culp B.M. and 1500 feet (460 m) southwest of St. Johns Church.

2. B.		LATITUDE N	LONGITUDE W
A.	Albright	40° 34′ 15″	78° 15′ 50″
B.	Fleck N	40° 34′ 14″	78° 16′ 20″
	Fleck S	40° 34′ 10″	78° 16′ 19″
C.	Keystone Co. "Deep Shaft"	40° 34′ 25″	78° 16′ 09″
D.	Bridenbaugh NW	40° 34′ 42″	78° 16′ 09″
	Bridenbaugh SE	40° 34′ 34″	78° 16′ 04″
E.	Ramey shaft	40° 35′ 06″	78° 16′ 13″
	Ramey outcrop	40° 35′ 07″	78° 16′ 16″
F.	Crissman ENE	40° 34′ 40″	78° 15′ 33″
	Crissman WSW	40° 34′ 39″	78° 15′ 35″
G.	Mary Isett N	40° 35′ 16″	78° 14′ 50″
	Mary Isett S	40° 35′ 07″	78° 14′ 50″
H.	McMullen	~40° 36′ 56″?	~78° 15′ 43″?
I.	Kryder	40° 37′ 05″?	78° 15′ 04″?
J.	Westley	40° 34′ 24″?	78° 15′ 58″?
K.	Albright milkhouse	40° 33′ 54″	78° 15′ 46″
L.	"Bear Hollow"	40° 34′ 06″	78° 15′ 58″
M.	R. Fleck milkhouse	40° 34′ 46″	78° 15′ 47″
N.	Crawford	40° 35′ 30″	78° 15′ 16″

C. TOPOGRAPHIC MAP: Occurrence G is in the Spruce Creek 7½-minute quadrangle. All the others are in the Bellwood 7½-minute quadrangle.

3. *Host Rock:* Based on distribution of prospects, these occurrences are probably stratigraphically controlled despite their generally vein-like nature. The host to the veins ranges from dolomite of the Upper Bellefonte Formation of the Beekmantown Group to interbedded limestone and dolo-

mite of the Loysburg Formation. Thus, the host ranges from upper Lower Ordovician (Canadian) to lower Middle Ordovician (Chazyan) in age.

Occurrence	Host Rock
A. Albright	Succession of dolomites and limestones (Platt, 1881, p. 270); dolomitic limestone (Reed, 1949a) of the Milroy Member of the Loysburg Formation. Beginning about 50 feet (15 m) south of the shafts, flat-pebble limestone conglomerate and fossiliferous limestone are common.
B. Fleck (south)	"Worm-bored" medium-dark limestone float on the knoll just south of the pit at the historical marker is probably the Grazier Member of the Hatter Formation. This would place the occurrences in the Clover Member of the Loysburg Formation.
C. Keystone Co. "Deep Shaft"	Probably the Milroy Member of the Loysburg. Platt (1881, p. 268) reports dark-blue dolomite for the wallrock.
D. Bridenbaugh	Light-gray laminated dolomite of the uppermost Bellefonte Formation.
E. Ramey	The shaft is in dark-gray dolomite of the uppermost Bellefonte Formation. The outcrop is in the Milroy Member of the Loysburg as indicated by interbedded limestone, dolomite, limy dolomite, and dolomitic limestone.
F. Crissman	Medium-dark, bluish-gray, thin-bedded limestone at the base of the Clover Member of the Loysburg Formation.
G. Mary Isett	
North Shaft	Dolomite with quartz rosettes of the upper Bellefonte Formation.
South shaft	Dolomitic limestone of the base of the Milroy Member of the Loysburg Formation.
H. McMullen	Gray limestone near Reedsville shale (Platt, 1881, p. 265). This does not fit Zeller's location, but Platt is probably correct.
I. Kryder	?, possibly Salona or Coburn Formations.
J. Westley	?, possibly Loysburg Formation.
K. Albright milkhouse	?, Loysburg Formation.
L. "Bear Hollow"	?, Loysburg Formation.
M. R. Fleck milkhouse	?, Bellefonte Formation.
N. Crawford	?, Lower Bellefonte Formation.

4. *Estimated Total Amounts of Ore Metals:*

A.

		<1 g	1-1000 g	1-1000 kg	>1000 kg
A.	Albright				Zn, Pb
B.	Fleck N			Pb?	Zn?
	Fleck S		Pb, Zn		
C.	Keystone Co. "Deep Shaft"			Pb	Zn[1]
D.	Bridenbaugh NW		Zn	Pb	Ba
	Bridenbaugh SE		Zn	Pb	
E.	Ramey shaft			Pb, Zn	
	Ramey outcrop		Pb, Zn		
F.	Crissman ENE		Zn	Pb, Ba	
	Crissman WSW			?[2]	
G.	Mary Isett N			Pb, Zn, Ba	
	Mary Isett S			Pb	Zn
H.	McMullen			Pb	Zn
I.	Kryder			?	
J.	Westley			?	
K.	Albright milkhouse		Pb?		
L.	"Bear Hollow"		Pb?		
M.	R. Fleck milkhouse			Pb?	
N.	Crawford		Pb?		

B. ASSAYS (from McCreath 1879, p. 279-280).

		Pb%	Zn%
A.	Albright	19.36	37.01
B.	Fleck	14.48	9.31
		11.95	28.16
C.	Keystone "Deep Shaft"	3-5[3]	25[3]
	Between "Deep Shaft" and Fleck house	6.22	45.36
G.	McMullen	.34	41.17
		.39	42.87

5. *Minerals Observed and Relative Amounts:*

A. ECONOMIC

		Major	Minor	Trace
A.	Albright	Galena, sphalerite (mostly dark-golden brown, some almost black),	Anglesite	Hydrozincite

1. Platt (1881, p. 267) reports the shipment of 300 tons of ore.
2. A question mark indicates the present author's guess as to the relative amounts of base metals. This guess is based on interpretation of Platt (1881) and more recent estimates.
3. Platt's (1881, p. 268) visual estimate of the average ore which would be yielded from the Keystone Zinc Company's "Deep Shaft" on the Borie farm.

		Major	Minor	Trace
		smithsonite (gray-white, mammillary and tan, earthy)		
B.	Fleck N[4]	?, Galena and sphalerite		
	Fleck S			
C.	Keystone Co.[4] "Deep Shaft"	?, Galena and sphalerite		
D.	Bridenbaugh NW	Galena (slightly deformed) smithsonite (white to gray, mammillary and tan, earthy)	Sphalerite (honey to golden-brown), hydrozincite, anglesite	
	Bridenbaugh SE	Smithsonite	Galena, anglesite	
E.	Ramey shaft	Galena, smithsonite, and sphalerite (golden-brown)		Anglesite
	Ramey outcrop		Sphalerite, galena	
F.	Crissman		Galena	Smithsonite, sphalerite, anglesite.
G.	Mary Isett N	Galena	Anglesite, smithsonite	Sphalerite (orange-brown)
	Mary Isett S	Sphalerite (yellow to orange)	Galena, smithsonite	
H.	McMullen[5]	Sphalerite		
I.	Kryder			
J.	Westley			
K.	Albright[6] milkhouse			Galena
L.	"Bear Hollow"[6]			Galena
M.	R. Fleck[6] milkhouse		Galena	
N.	Crawford			Galena
O.	Between "Deep shaft" and Fleck house			

B. GANGUE

		Major	Minor	Trace
A.	Albright	Barite		Pyrite
B.	Fleck N			
	Fleck S			
C.	Keystone Co.[7] "Deep Shaft"	Barite, dolomite	Calcite	
D.	Bridenbaugh NW	Barite	Dolomite (cream cleavages)	Quartz (acicular crystals in barite nodules)
	Bridenbaugh SE			
E.	Ramey shaft	Dolomite, barite		Pyrite (ovid in dolomite rock)
	Ramey outcrop		Dolomite	
F.	Crissman	Barite, dolomite	Quartz	Fluorite (purple)
G.	Mary Isett N	Barite (some clear, tabular microcrystals)	Quartz, dolomite	
	Mary Isett S	Dolomite (white)	Quartz, pyrite (disseminated small crystals along veins and larger ovids in rock matrix)	Dolomite (pink)
H.	McMullen			
I.	Kryder			
J.	Westley			
K.	Albright milkhouse			
L.	"Bear Hollow"[8]		Calcite	
M.	R. Fleck[8] milkhouse		Calcite, barite	
N.	Crawford			

4. From Platt (1881) rather than the present author's personal observations. Hence, the uncertainty indicated by the question marks.
5. Platt (1881, p. 264)
6. Zeller (1949, p. 51)
7. From Platt (1881, p. 267-268)
8. Zeller (1949, p. 51)

6. *Paragenesis:* For Bridenbaugh NW and Mary Isett S prospects: diagenetic barite, pyrite, and quartz nodules (possibly replacing very early anhydrite); brecciation; dolomite; galena; sphalerite, barite and fluorescent sphalerite; and supergene minerals.

7. *Geologic Description:* As mapped by Zeller (1949), the geology of the southern end of Sinking Valley consists of a simple, asymmetric, southwest-plunging anticline. Platt (1881, p. 249) noted that the anticline plunged at 7°. Accurate bedding determinations by John H. Way and the author[9] indicate more complex structure on the portion of the Fred A. Good farm west of Culp (see Figure 49). Here, a substantial number of good outcrops yield nearly east-west strikes, whereas the area was expected to be on the crest of the anticline and yield northwest strikes. Folding of the Sinking Valley anticline itself or minor folding and faulting within it are most likely. Geologic mapping by the Pennsylvania Geological Survey will continue as part of the Altoona 15-minute quadrangle project.

As noted by Moebs and Hoy (1959, Figure 2) and Gwinn (1964, Figure 14), the axis of the Sinking Valley anticline is arcuate. Gwinn (1964, p. 883) accounts for the arcuate trend change and concomitant plunge by a southwestward decrease in the amount of override of the hanging wall sheet onto the higher decollement glide zone.

In general, the better zinc-lead occurrences are confined to a stratigraphic zone which rims the southern half of the valley. This zone extends from the Tea Creek Member of the Bellefonte Formation to the Milroy Member of the Loysburg Formation. Should the known type of occurrence become economically interesting, prospecting should obviously continue down plunge beneath Sickles Corner. Within this stratigraphic interval, the veins are localized in northwest-trending high-angle faults with apparently small vertical components of displacement. For example, Zeller (1949, p. 50) notes that the Fleck occurrences ([B.] of this report) are along a 725-foot-(220 m) long vein which trends N48W (Platt reports N40W) and the Bridenbaugh occurrences ([D.] of this report) are along an 1100-foot-(340 m) long vein which trends N30W. Possibly the Ramey (E), Westley(?, I), and Albright (A) occurrences lie along an extension of this latter vein system. Based on a lack of float, however, a continuous vein is unlikely. Hand samples from occurrence D show an angle between a vein and bedding of 85 ± 5°. Reed (1949, p. 5) notes that the vein on the Albright farm strikes nearly east and dips 80 to 85° to the north. Such crosscutting veins are not apt to be economic deposits. Of more interest are "veins" parallel to bedding; these could be more economic replacements. The Keystone mine near Birmingham may be of this type[10] as may be the two Mary Isett prospects (Platt,

9. The median strike and dip of at least three determinations each by Way and Smith, using different surfaces, has been used in Figure 49.

10. A. W. Rose, of The Pennsylvania State University, interprets the Keystone mine ore as basically crosscutting, with local replacement along bedding. The present author agrees but places greater emphasis on the stoped, high-grade, replacement(?) ore.

1881, p. 271). Although no prospects are known at the horizon of the Axemann Formation, this zone where the Axemann limestone may have been replaced by coarse-grained Bellefonte-like dolomite of suitable texture and permeability for replacement should be thoroughly tested. Here, larger strata-bound occurrences are possible which could predate vein leakage(?) developed during the Appalachian Orogeny. If no surface targets of Axemann are available, a possible deep target would be the peculiar siliceous area about 1500 feet (460 m) northwest of the Fred Good barn. This area is just east of the possible vein system through occurrences D, E, I, and A. Silicification here may have been caused by spent hydrothermal solutions leaked from Axemann dolomite at depth.

Data on individual occurrences are listed below.

A. The Albright occurrence originally consisted of a shallow 8- to 10-foot (2.5 to 3 m) shaft and a vertical drill hole continuing 100 feet (30 m) from the bottom of the shaft. The core consisted of a succession of dolomites and limestones with traces of sphalerite, galena and pyrite in the upper 20 feet (6 m) (Platt, 1881, p. 270). Reed (1949a, p. 5) reports that an Ohio company dug a 40-foot (12 m) vertical shaft into the footwall 125 feet (38 m) east of the first shaft in 1920. This company also churn-drilled a 213-foot (64.9 m) hole in the hanging wall about 50 feet (15 m) east of the old shaft and is reported to have found ore.

In 1949, Zeller reported two pits about 30 feet (9 m) in diameter and about 15 feet deep lying almost east and west of each other about 200 feet (61 m) apart. The eastern pit seemed to be the deeper based on a waste bank of fresh limestone extending 50 feet (15 m) from the hole. These pits were said to have been dug out by a party from Missouri.

Mr. John Tremmel, a resident at the occurrence, reports that the shafts were sunk by a group from Oklahoma who found too much mundic (pyrite) in the ore, and he claims that the property was drilled by The New Jersey Zinc Company in the 1950's; it is well known locally that the same company drilled elsewhere in Sinking Valley. Mr. Tremmel also indicated that there are "several . . . patches where only weeds grow" on the Earl Albright farm; these were verified by the author.

In 1947 the U. S. Bureau of Mines examined the area. Three bulldozer trenches across the vein discovered two additional, small veins (see Figure 3 from Reed, 1949a). Three cores were drilled as follows:

Hole	Location	Bearing	Inclination	Results
1	145 feet (44 m) NW of old shaft	S16E	60°	Intersected "three" veins with trace mineralization in the two more northerly veins at 121 and 122 feet (37 m), 131 to 143 feet (40 to 43 m),

				and 155.5 (47 m), 158 (48 m), 159 (48 m), and 163.5 feet (50 m).
2	100 feet (30 m) E of hole 1 and 75 feet (23 m) N of vein	S16E	60°	Specks of galena from main vein at 128.5 to 130 feet (40 m). Crevice from 164 to 183 feet (50 to 56 m). White crystalline limestone from 44 to 46 feet (13 to 14 m).
3	100 feet (30 m) W of hole 1 and 75 feet (23 m) N of vein	S16E	60°	Trace of pyrite at 40 and 61 feet (12 to 19 m).

If, however, the vein trends about N30W through the old Tatham shaft (A), Westley's (I), and Bridenbaugh's (D), then the drilling did not test the vein. An additional drill hole collared 100 feet (30 m) due north of the old shaft and trending S20E with a 45° inclination is needed.

B. The Fleck occurrences were described by Platt (1881, p. 268-269) as consisting of two parallel fissure veins about 130 feet (40 m) apart which trend N40W and cut bedding at high angles. The northeast vein was reported by Mr. Fleck to be 1-foot- (30 cm) thick and have calcite on each wall. It has been prospected by a 27-foot (8.3 m) shaft, a 40-foot (12 m) shaft, and at least two pits. Morrison Cove sheet number 4 locates shafts on the northwest edge of the road (historical marker area?) and 475 feet (145 m) N60W from this. A third shaft is located 600 feet (185 m) N77W of the road edge shaft (historical marker area?) and about 175 feet (53 m) S65W of the northern shaft.

Platt (1881, p. 269) also mentions an isolated opening on a small vein between Mr. J. G. Fleck's house and the Keystone Company "Deep Shaft" about which he could obtain only a little information. Entry to this property was restricted during the present study and no additional information is available.

Zeller (1949, p. 50) describes the former location of a shaft as about 100 feet (30 m) south of the old Earl Albright house, on the southeast side of the paved road, and just south of the farm lane toward "Bear Hollow." This shaft would be across the paved road from the shaft located on Morrison's Cove sheet 4 which is now probably the site of the historical marker. The "orchard shaft" of Zeller is probably the one referred to by the historical marker as being about 400 feet (120 m) north of the marker's location. From this shaft, Zeller traced ore float N48W for 725 feet (220 m) and found a recently caved-in shaft in an orchard along the vein.

C. The Keystone Company's "Deep Shaft" is reported by Platt (1881, p. 267) to have been dug over 80 feet (24 m) deep following a small fissure vein which was 3 to 4 inches (8 to 10 cm) at the surface and 14 inches (36 cm) at the bottom of the shaft. Calcite coated the vein walls. Trial pits were put down about 125 feet (38 m) N57W and about 200 feet (62 m) N57W of the "Deep Shaft," and are said to have encountered a fissure vein. Platt believed these pits, the "Deep Shaft," and Westley's could be on the same vein, but the Morrison's Cove sheet 2 locates them such that a single vein is unlikely. Because of its production, this occurrence deserves additional prospecting. A small vein which yielded excellent Pb-Zn ore was reported between the "Deep Shaft" and Mr. Fleck's house (Platt, 1881, p. 269).

D. Platt reported that the Bridenbaugh occurrences were prospected with a few shafts and crosscuts. Mr. Dickerson reported to Platt that most of the shafts encountered ore, and that one vein was 8 inches (20 cm) wide, trended northwest and was very similar over the 25 feet (8 m) it was followed vertically. Platt (1881, p. 265) noted that the ore around this shaft was lean in galena and sphalerite, but that barite was abundant. This description fits best with the northwest Bridenbaugh occurrence.

Zeller (1949, p. 48) states that the Bridenbaugh shaft was originally 80 feet (24 m) deep and that it had recently collapsed to a 10-foot- (3 m) deep hole about 20 feet (6 m) in diameter. Zeller traced barite and galena float more than one quarter mile (400 m) on a N25W trend, in good agreement with the N27-31W trend of the present study. Hand specimens show an $85 \pm 5°$ angle between veins and bedding.

Both the northwest and southeast Bridenbaugh occurrences are readily located by means of vegetation anomalies. Mr. Fred A. Good reports that about 24 shallow cores were drilled on his property about 1960; most holes were near the northwest occurrence. Mr. Good did not know the results of the drilling, but if done by a reputable company, the number of holes may indicate more than trace mineralization. He does not believe that the siliceous area west of his barn was tested.

E. The Ramey occurrences were only mentioned by Platt (1881, p. 266) as follows:

> . . . in one of the Raemy (sic) fields the scattered fragments of ore are quite abundant. And here it was that the shaft and open cut referred to in Mr. Dickerson's report were made some years ago.
>
> "The vein," says Mr. Dickerson, "was struck in both cases, . . . and in character did not differ from all the others."

The mineralized outcrop of interbedded limestone, dolomite, limy dolomite and dolomitic limestone contains northwest-trending, millimeter-wide veinlets of sphalerite and galena. The shaft (now filled) area with abundant barite, smithsonite, galena, and sphalerite contains abundant limestone float, but the outcrops are dolomite. If the outcrop and shaft are on the same fissure, the vein trends about N65W. The proximity to the siliceous area should be noted on Figure 49, the bedding data map.

F. The Crissman occurrences could not be correlated with known occurrences with certainty. They could either be located (1) on the present Robert S. Black farm as assumed by Reed and the author, based on Platt's (1881, p. 266) locating them near the grist mill, the reported limestone host, and the fact that Sam Black bought the farm directly from Crissman's in about 1919 (R. S. Black, personal commun., 1973), or (2) on the Roller Fleck farm as assumed by Zeller, based on Platt's locating them about a quarter mile (400 m) east of the Bridenbaugh pits. The two pits on the Black farm are about 225 feet (70 m) apart on a bearing of N85E.

Platt (1881, p. 266) described the three veins on the Crissman farm as follows:

> Vein 1 — No description.
>
> Vein 2 near the lane was exposed by an open cut for 40 feet (12 m) along the vein. It contained barite, galena and sphalerite in dark limestone.
>
> Vein 3 had an old prospect shaft 15 feet (4.6 m) from which shaft No. 1 was sunk for 6 feet (2 m). Shaft No. 2 was sunk 40 feet (12 m) along the vein (probably south) for a depth of 5 feet (1.5 m) and exposed a 3 foot (0.9 m) vein of barite, galena, sphalerite, and limonite in a crystalline limestone. Shaft No. 3 was sunk 50 feet (15 m) beyond to a depth of 10 feet (3 m) exposing a similar vein which was 4 feet (1.2 m) wide. Shaft No. 4 was sunk 75 feet (24 m) beyond to a depth of 6 feet (2 m) exposing an 18-inch (46 cm) vein in a hard, cherty limestone.

A Mr. Williams reported to Platt that barite and galena were more abundant than zinc.

G. The Mary Isett occurrences were reported by Platt (1881, p. 271) to have been prospected by two shafts about 1000 feet (300 m) apart and nearly north-south from each other. The veins were reported to be 2 feet (60 cm) wide each and to strike N60E, parallel to the strike of bedding. Because of this latter feature, they warrant further prospecting.

At present, the Mary Isett south prospect consists of a 30-foot- (9 m) long and 15-foot- (5 m) wide dump located about 25 feet (8 m) southeast of the probable shaft location. The dolomitic limestone on the dump contains mineralized flat-pebble conglomerate, tectonic breccia, and a few pieces of probable collapse breccia, all mineralized with minor sphalerite and traces of galena. The Mary Isett north prospect consists of a 25-foot (8 m) circular depression which is about 3 feet (1 m) deep. Mineralized float occurs to the northeast. A. V. Heyl (personal commun., 1976) notes that he traced the vein system a substantial distance still farther to the northeast.

About 4300 feet (1300 m) northeast of the Mary Isett south shaft, there is a well-exposed collapse breccia on both sides of the highway. The collapse breccia trends N55W, similar to a pronounced joint set which trends N55W, 85SW. The collapse breccia is 6 feet (2 m) wide and cemented with a clear calcite spar. No zinc or lead was observed, but this outcrop may demonstrate the existence of collapse breccia just above the top of the

Beekmantown Group. The collapse breccia appears younger than a slickenside lineation which strikes N67W and plunges about 30E on a bedding surface which trends about N85E, 29SE. Also, in this case, the available evidence does not rule out a recent cave breccia.

H. The McMullen occurrences were prospected by two shafts about 75 feet (23 m) apart. The south vein varied from 6 to more than 12 inches (15 to 30 cm) in width, the center 6 inches (15 cm) being composed of rich sphalerite with little galena. The vein is reported to trend N35W (Platt, 1881, p. 264). Platt's statement that the occurrence was near a limestone-shale contact and the farm map of Nichols (1873) showing iron ore pits suggest that Zeller's location may have been incorrectly associated with an iron mine. Zeller (1949, p. 55) described a more recent scheme which found a ½-inch (0.13 cm) galena vein striking northeast, but like the author, was unable to find a trace of base metal ore in this area. The present author, however, only checked the area of Zeller's No. 9.

I. The Kryder occurrences are believed to be located near the McMullen's occurrences and Scalp Level (Skelp), but were not located. Platt (1881, p. 265) furnishes little information except that ore float is abundant southwest of Mr. Kryder's house.

J. The Westley occurrence (Platt, 1881, p. 267-268) is reported to have been a vein similar to the Keystone Company's "Deep Shaft."

K. The Ernst Albright milkhouse occurrence was reported by Zeller (1949, p. 51) to have yielded galena.

L. The "Bear Hollow" occurrence was reported by Zeller (1949, p. 51) to have consisted of two, 10-inch (26 cm) calcite veins with traces of galena.

M. The Roller Fleck milkhouse occurrence was reported by Zeller (p. 51) to have consisted of a shaft which caved in a few years prior to 1949. The excavation for Mr. Fleck's barn revealed veins containing galena and barite in calcite. This area could be the Crissman prospects of Platt, but he reports a limestone host in contrast to the dolomite on the Fleck farm.

N. The Crawford post hole occurrence was reported by Stanley Crawford (personal commun., 1973) to contain minor galena.

Further exploration in Sinking Valley is warranted for the following reasons:

1) Favorable interbedded limestone and dolomite host rock (Bellefonte to Loysburg Formations) believed to contain "collapse breccias" in some areas of central Pennsylvania.

2) Apparent dolomitization of the Axemann Formation limestone which is usually present between the Bellefonte and Nittany dolomites, both of which are known to contain zinc and lead in this area.

3) Anomalous silicification between known zinc-lead prospects.

4) Possible stratigraphic control of vein deposits.

5) Presence of numerous prospects which could represent "leakage" from larger deposits elsewhere in the geologic section.

6) Scattered, pre-tectonic mineralization in the form of pyrite and barite.

Past exploration appears to have been aimed solely at near-surface, vein deposits.

23. TRIANGLE OR THREE CORNERS MINE, LEHIGH COUNTY

(Former Zinc Producer With Possible Reserves)

1. *Name:* Variously called the Triangle or Three Corners mine by the owner, The New Jersey Zinc Company. Miller (1924, p. 84) used the name Three-cornered Lot mine.

2. *Location:* A. The Triangle mine open cut is located 700 feet (215 m) north-northeast of the intersection of East Saucon Valley Rd. and Old Bethlehem Pike at Friedensville, Upper Saucon Township, Lehigh County (Figures 32 & 33). The open pit is 550 feet (170 m) west-northwest of the intersection of East Saucon Valley Road with Pa. Route 378 and 0.7 mile (1.1 km) due north of the bridge of that route over Saucon Creek.

B. LATITUDE N: 40° 33′ 39″ LONGITUDE W: 75° 23′ 11″(Open Pit)

C. TOPOGRAPHIC MAP: Allentown East $7\frac{1}{2}$-minute quadrangle.

3. *Host Rock:* Lower Ordovician Rickenbach Formation, a silty medium-dark-gray crystalline dolomite, which comprises the base of the Beekmantown Group.

4. *Estimated Total Amounts of Ore Metals:*

A. <1 g:
   1-1000 g:
   1-1000 kg: Cd
   >1000 kg: Zn

B. ASSAYS: None, but there is a 5-foot (1.5 m) ore zone visually estimated to contain 5–10% Zn exposed in the north-northwest corner of the pit.

5. *Minerals Observed and Relative Amounts:*

A. ECONOMIC

Major:	Sphalerite (gray to yellow in dolomite and bright-lemon-yellow in quartz)
Minor:	Hemimorphite[1]
Trace:	Greenockite and smithsonite

B. GANGUE

Major:	Pyrite (cubes modified by octahedrons, etc.), dolomite (white, crystalline in veins) and quartz (clear, colorless in veins, some fibrous and crystals in vugs)

1. Hemimorphite was undoubtedly the first ore mineral to be recovered during the 19th century. Following exhaustion of oxidized ores, the same operation mined sphalerite.

Minor: Calcite (white, crystalline in veins) and black chert
Trace:

6. *Paragenesis:* Gray-yellow sphalerite and pyrite; white dolomite, quartz, and lemon-yellow sphalerite; white calcite; supergene hemimorphite, smithsonite, and greenockite.

7. *Geologic Description:* Callahan (1968, p. 101) "shows the structure in the vicinity of the mines to be a southwesterly plunging (18°), overturned anticline, with vertical north limb at the Ueberroth mine, and a moderately inclined south limb at the Triangle, Correll, and New Hartman mines." Bedding at the west side of the Triangle mine was measured as N88W, 35S; whereas on the east side, N86E, 23S was measured. This latter attitude suggests that the Cemetery cross fault's (Callahan, 1968, Fig. 5, p. 103) offset may be small or not absolutely necessary, and that offset between Correll and Triangle mine ore horizons could be due to minor folding. Certainly, the bedding determinations of N68E, 33S measured on the north rim suggest some folding within the pit and that perhaps the N88W strike is the anomalous one. Drilling to the southwest of the Triangle mine suggested a strike of N79E (White and Bell, 1948). Similarly, Figure 33 (Miller, 1924, p. 83. Map courtesy of The New Jersey Zinc Company) shows no offset of ore beneath Old Philadelphia Road (now Old Bethlehem Pike) to the west of the Triangle mine. Drilling along the southeast side of Pa. Route 378 is suggested to determine the true attitude in this area.

Fair-grade ore (5-10% Zn) occurs in the upper rim of the north-northwest side of the Triangle mine. The ore zone consists of 5 feet (1.5 m) of collapse breccia with a partial matrix of sphalerite and disseminated sphalerite in clay-carbon insoluble residue. This is apparently the zone followed westward by means of underground workings (Miller, 1924, p. 831, Figure 7). Trace to minor sphalerite was also observed in the gully leading into the northeast end of the open cut. Minor pyrite, hemimorphite, limonite, and quartz were observed in the east central and south-southwest faces. White and Bell (1948) encountered near ore-grade sphalerite in diamond drill holes 3 and 5, on another property to the south and southwest of the open cut.

Miller's Figure 7 (1924, p. 83) indicates that the mine was 55 feet (17 m) deep and infers that the ore dips 32° to the south. Small, very low grade (0.1-1% Zn) dumps occur on the north rim of the open pit, and washings from concentration of silicate ore occur northeast of the pit.

Near the old water gauge station on the rib on the west side of the pit there is a distinctive outcrop of laminated rock which might serve as a marker bed. This 4-foot- (1.2 m) thick bed weathers to a well-laminated surface. When fresh, thin dark-gray laminae can be seen in a more buff-colored matrix of medium- to finely-crystalline dolomite. Another possible marker bed is an algal laminite with some flat-pebble conglomerate. The chips (½ × 2 inches or 1 × 5 cm) in this conglomerate are also laminated.

24. UEBERROTH MINE, LEHIGH COUNTY

(Former Zinc Producer With Large Probable Reserves)

1. *Name:* Ueberroth mine, owned by The New Jersey Zinc Company.

2. *Location:* A. The Ueberroth mine is located in Saucon Valley, Upper Saucon Township, Lehigh County. The mine is 0.45 mile (0.7 km) north-northwest of the intersection of East Saucon Valley Road with Old Bethlehem Pike at Friedensville, 600 feet west of Old Bethlehem Pike, and 0.4 mile (0.65 km) southwest of Colesville. See Figure 32 for the location of the Ueberroth and other open pits in the Friedensville district.

B. LATITUDE N: 40° 33′ 56″ LONGITUDE W: 75° 23′ 52″

C. TOPOGRAPHIC MAP: Allentown East $7\frac{1}{2}$-minute quadrangle.

3. *Host Rock:* Lower Ordovician Rickenbach Formation of the Beekmantown Group. Drake (1965) describes the Rickenbach Formation as a silty and sandy medium-dark-gray crystalline dolomite with some boulder conglomerate and sedimentary breccia. The author has observed both flat-pebble conglomerates and collapse breccias in the Friedensville area. Much of the dolomite on the southeast rim of the Ueberroth is laminated. A marker bed of dark sandy dolomite known as the Trihartco is in the ore zone (Callahan, 1970, p. 100).

4. *Estimated Total Amounts of Ore Metals:*

A. <1 g:

1-1000 g:

1-1000 kg: Cd

>1000 kg: Zn, (Clerc, 1882, reported 300,000 tons of hemimorphite and smithsonite. In addition, a large but unknown amount of sphalerite-bearing ore with a grade of 15-25% Zn was produced.)

B. ASSAYS: In the early years, the shipped ore ran 35-40% Zn. This was produced by selective mining of oxidized ore. Gilbert and Wetherill (1855) report an average recovery of 40% Zn from the ore. Wittman and others (1847, p. 3) report an assay of 47.6% Zn ". . . on a sample obtained by mixing a large mass of the ore, taken promiscuously, as it came out from the mine." Oxidized ore concentrates during the main period of mining (late 19th century) contained about 20% Zn with the tailings sometimes being richer (Miller, 1924, p. 75-76). The best, hand-picked sphalerite ore contained 40-42% Zn, and the remainder contained 15 to 25% Zn (Miller, 1924, p. 76).

5. *Minerals Observed and Relative Amounts:*

A. ECONOMIC

Major:	Sphalerite (early gray in breccia matrix and veins and late lemon-yellow in veinlets)
Minor:	Hemimorphite (limonite masses, botryoidal plates, and small crystals)[1]
Trace:	Greenockite, bianchite,* goslarite,* smithsonite,[2] sauconite,[1,3] hydrozincite.

B. GANGUE

Major:	Pyrite (disseminated and in centers of gray sphalerite veins), dolomite (white crystalline), quartz (milky white to clear, colorless)
Minor:	Gypsum,* epsomite,* limonite
Trace:	Muscovite var. sericite, calcite

6. *Paragenesis:* Solution of rock dolomite host; hypogene gray sphalerite tending to yellow gray, pyrite; tectonic deformation; sericite, yellow sphalerite; quartz; dolomite; calcite; supergene hemimorphite, smithsonite, hydrozincite, and limonite. The black chert could be diagenetic or hypogene jasperoid.

There may have been more than one period of pyrite or quartz formation and the relative order of formation of supergene minerals may vary locally.

7. *Geologic Description:* The structure in the vicinity of the zinc mines at Friedensville is a southwesterly plunging (18°) overturned anticline, with a vertical north limb at the Ueberroth mine (Callahan, 1968, p. 101). Bedding in the Ueberroth open pit varies slightly as follows: north central part of southeast rim, N65E, 88SE; southwest end of southeast rim, N55E, 90°; southwest floor N59E, 90°; northeast end of northwest rim N67E, 85SE (Fig. 2); and southwest end of northwest rim N58E, 90°. In general, it appears that bedding in the northern part of the Ueberroth open pit is about N66E, 86SE, whereas for the southern part it is N57E, 90°. Thus, the author would project the key stratigraphic Trihartco marker (which the ore generally follows) northeast on a bearing of N66E, versus the N45E estimated in Figure 5 of Callahan (1968, p. 103). Figure 51 (Miller, 1924, p. 80), a map of the Ueberroth mine furnished by The New Jersey Zinc Company, shows the Trotter Vein trending about N45E and the Stadiger Vein about N50E. These, however, may be true veins (Figure 52) and hence oriented differently than the horizon of ore in collapse-rubble breccia and overlying crackle breccia. From bearings taken in the open pit and the Allentown East 7½-minute topographic map, the long axis of the open pit is about N60 and 70E. In agreement with this and the map of Wittman and others (1847) (Figure 53), a Mr. Detweiller, former Chief Chemist for the Lehigh Zinc Company, reported to A. V. Heyl (circa 1930) that oxidized zinc-ore float was common in the fields on the order of 3000 feet (900 m) north to northeast of Friedensville. A geochemical soil sample traverse along the Lehigh-Northampton

1. It is known that prior to mining immense tonnages of hemimorphite, sauconite and possibly smithsonite existed within a few hundred feet of the surface. However, only one series of sauconite shipments is reported by Miller (1924, p. 62).
2. A. V. Heyl (personal commun., 1976) takes exception and reports that smithsonite is now a minor or major mineral.
3. Despite a lead isotope value reported by Brown (1968, p. 9) from earlier researchers, galena has never been found in the Friedensville district (W. H. Callahan, personal commun., 1973).

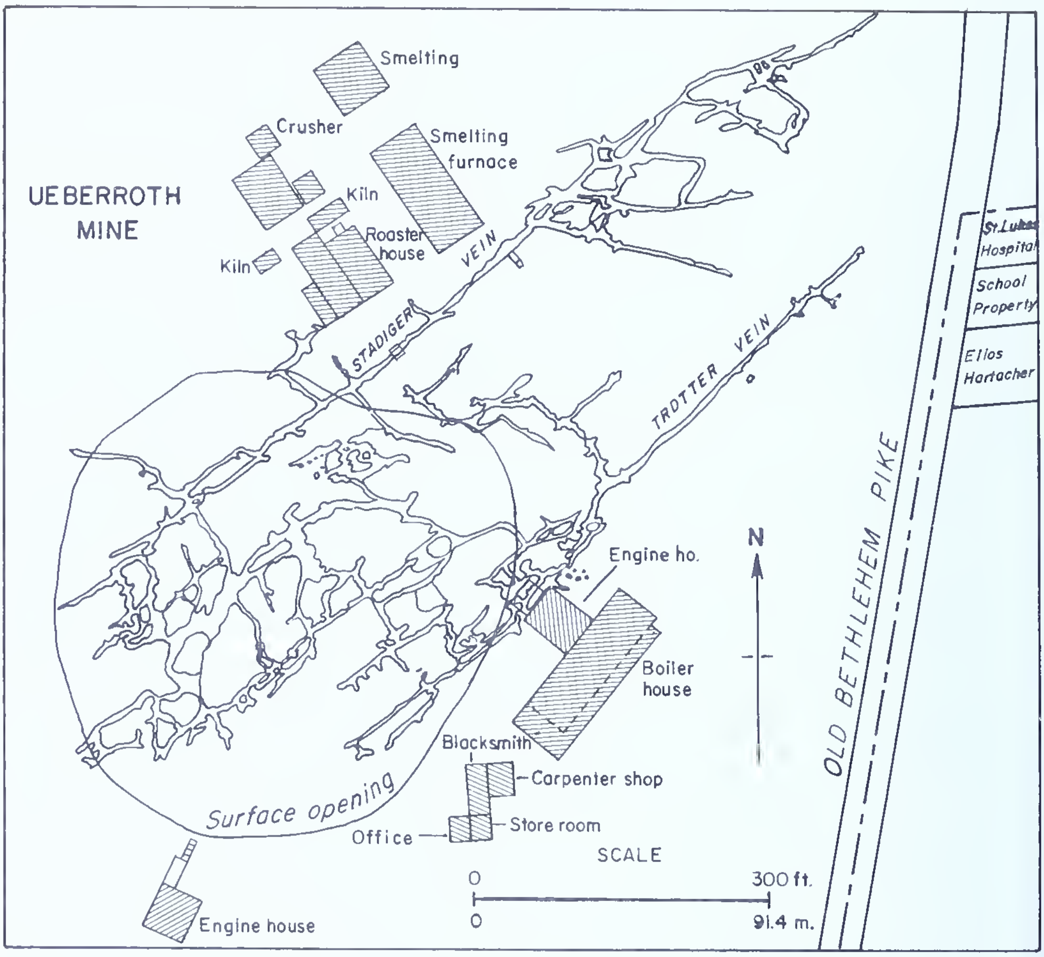
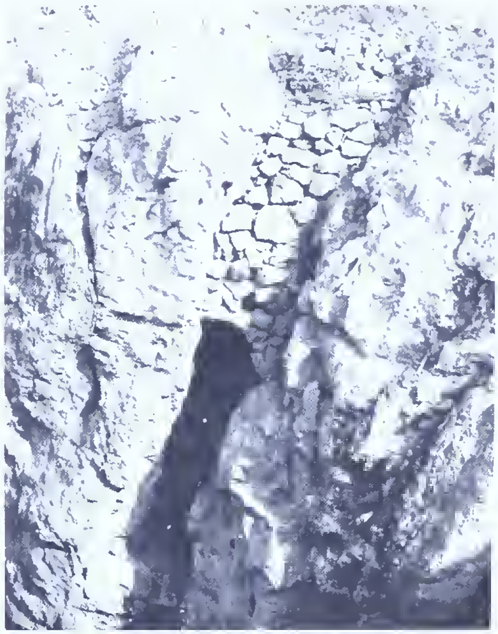


Figure 51. Distribution of sphalerite-bearing veins in the Ueberroth mine, Friedensville, Lehigh Co. (Miller, 1924, and The New Jersey Zinc Co.).

County line between Pa. Route 378 and E. Saucon Valley Road could test this possible extension.

Sphalerite is observable at many places in the walls of the Ueberroth open pit. The southeast rim and southwest end, in particular, contain areas of ore. The northeast end of the northwest rim appeared to the author to be rather barren. It contains trace limonite after pyrite and very abundant, scoriaceous milky quartz which weathers in relief. At the southwest end of the northwest rim rib there is minor gray sphalerite and a 1-foot- (0.3 m) wide vertical zone of hemimorphite which trends due north. Near the southwest end of the northwest rim there are numerous vertical, bed-parallel gray sphalerite and pyrite veins from ½- to 3-inches (1 to 5 cm) thick which trend N58E. These veins are not symmetrical in cross section, but are slickensided on one side, which also has a minor pyrite zone. The major pyrite zone is usually in the center of each vein. These relations suggest that the veins formed during deformation, with pyrite generally later than sphalerite. Such tectonic-induced remobilization could enhance or displace the geo-

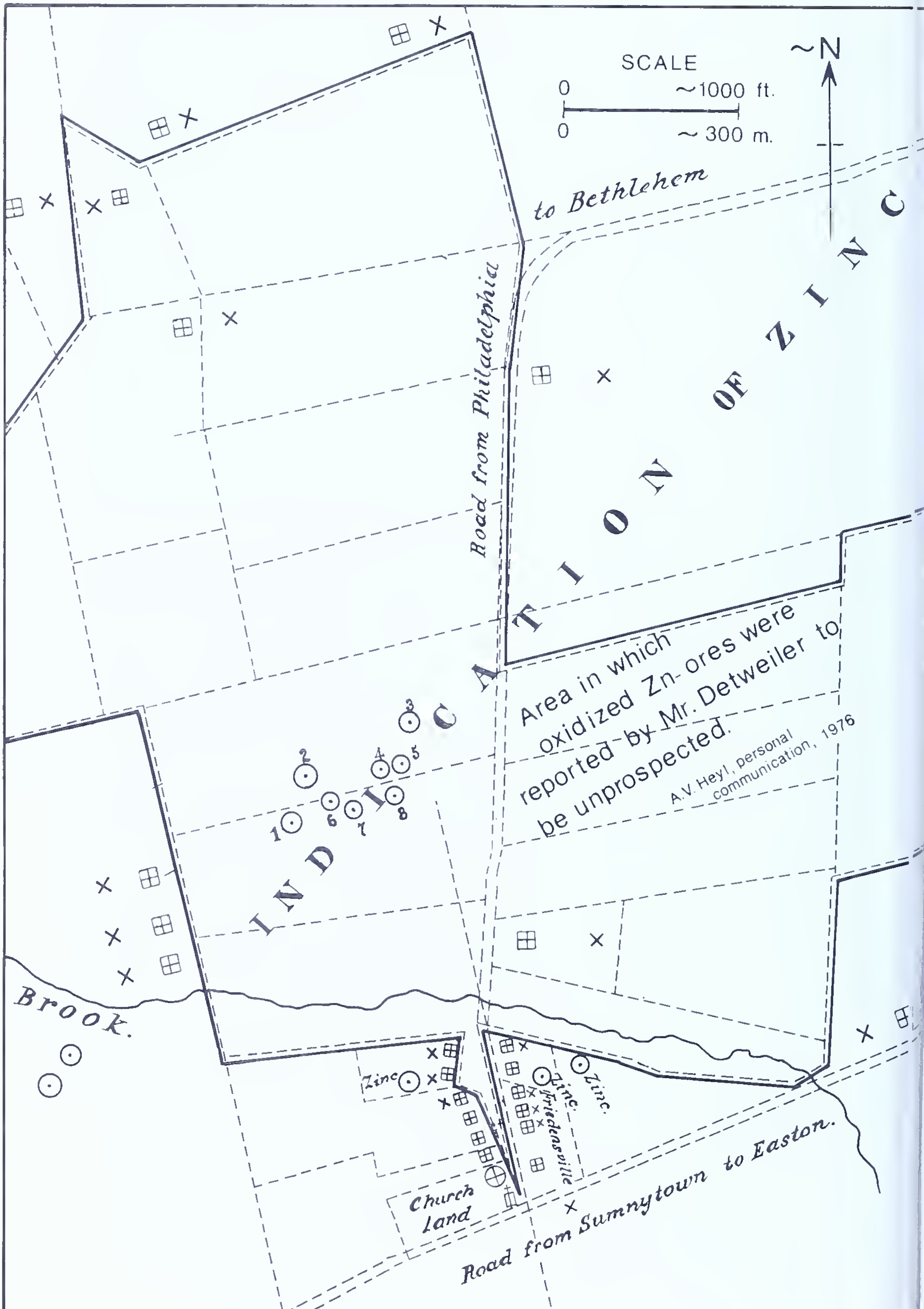
Figure 52. Partly-filled workings which followed a sub-vertical bed or vein dating from the last century. The view is to the northwest across the northeast end of the Ueberroth mine, Friedensville, Lehigh County.



chemical halo over any ore bodies at depth. The host to these veins is a well-laminated dolomite. Sulfate mineral crusts (Figure 54) are very abundant on the laminated dolomite and on the false-floor of the Ueberroth below these veins. Most common are bianchite and gypsum as an off-white to buff, fluffy powder and goslarite and epsomite as clear, crystalline, sponge-like masses. It is almost certain that similar minerals formed prior to mining, and that rains after dry spells released moderate quantities of zinc sulfate into the ground water.

Most of the apparent floor of the Ueberroth is a false-bottom timber mat (Figure 55). Thus, only the southern edge of the pit bottom was examined. Based on resonance and local magnetic anomalies, it was eventually decided that even the southwest end is probably a false bottom. Figure 5 of Miller (1924, P. 80) remains the best available map of the Ueberroth veins. Clerc (1882) indicates that the mine was worked to a depth of 225 feet (70 m), that the ore "dipped" (plunges?) regularly to the southwest, and that six parallel northeast-trending veins and about as many cross-veins were mined. The richest ore occurred at vein intersections.

From Whittman and others (1847), it is known that mining at the Ueberroth began via 8 shafts with an average depth of about 30 feet (9 m) each of which stayed in hemimorphite from about 10 feet (3 m) below the surface to the bottom (Figure 53). Andrews (1853, p. 7) reported the construction of a two-horse whim to raise both water and ore at the same time: the contrivance "it is believed, will save the Company a large outlay required for a steam-engine to do the same work." However, by 1872, the Ueberroth mine was pumping up to 12,000 gallons/minute with the largest pump in the world (Figure 56), and the mine itself was one of the largest zinc mines.


SCALE
0 ~1000 ft.
0 ~ 300 m.
~N
to Bethlehem
Road from Philadelphia
INDICATION OF ZINC
1
2
3
4
5
6
7
8
Area in which oxidized Zn-ores were reported by Mr. Detweiler to be unprospected.
A.V. Heyl, personal communication, 1976
Brook.
Zinc
Zinc.
Zinc.
Friedensville
Church land
Road from Sumnytown to Easton.

Andrews also reported that a tornado leveled the zinc-oxide plant in South Bethlehem as workmen were about to construct the roof, but the building was soon rebuilt.

Miller (1924, p. 76) noted that

> A common belief that the Friedensville mines were closed on account of the exhaustion of the ore is incorrect, because the ore bodies were as large in the lowest workings as near the surface, the veins gave no evidence of dying out as the depth increased, and the sulfide ores showed little change in tenor. How much ore remains is purely a matter of conjecture, but there is every reason to believe that the mines can still furnish a large tonnage of sulfide ore as well as considerable calamine and smithsonite ore.

B. L. Miller was a cautious geologist, and his conclusion as to the Ueberroth and other ore bodies at Friedensville remains true today.

Rather curiously, the Ueberroth ore was first tested in 1830 at Mary Ann iron furnace in Berks County. The experiment failed to yield iron.

REFERENCES.

⊞ × Buildings and outbuildings
Church.
⊕ Schoolhouse.
⊙ Shafts.

Nº 1	Shaft.	37 feet.	Depth	through	zinc ore	31 feet.
″ 2	″	42	″	″	″	30 ″
″ 3	″	13	″	″	″	9 ″
″ 4	″	53	″	″	″	46 ″
″ 5	″	27	″	″	″	16 ″
″ 6	″	30	″	″	″	22 ″
″ 7	″	33	″	″	″	24 ″
″ 8	″	22	″	″	″	12 ″

In none of the Shafts has the zinc ore been penetrated. (That is, the bottom is in ore)

Figure 53. An early map of the Friedensville zinc district (Wittman and others, 1847) courtesy of A. V. Heyl.

Figure 54. View of the northeast end of the Ueberroth open cut showing vertical bedding, underground drifts (white arrow) following selected beds or veins, and white secondary sulfate incrustations (black arrow).

Figure 55. View to north down incline beneath the timber-mat floor of the Ueberroth mine, Friedensville, Lehigh County. The mat was constructed during the last century to protect miners from rockfalls. The horizontal timber in the foreground is inaccessible, but estimated to be about 3 feet in diameter.

Figure 56. View of narrow workings in Ueberroth open pit, drifts to the side, and building foundation for the President engine pump, rated at 17,000 gallons per minute in 1872. At the time, this was the largest pump in the world. The view is to the east-northeast from the northwest rim.

25. WOODBURY PROSPECT AREA, BEDFORD COUNTY

(Abandoned Lead-Zinc Prospects With Potential In Area)

1. *Name:* The Woodbury prospect is so designated despite its being about 3 miles (5 km) west of the town of Woodbury, because the name "Woodberry" was used by the Second Pennsylvania Geological Survey. The principal farms which may contain zinc-lead mineralization include: Roy Barley, Ira and Mira Claar, G. W. Clause, D. E. Ellis and L. B. Parsons, Galen L. Furry, D. E. Glasgow, G. L. Long, Elwood Smith, Jacob J. Snyder, and Ray E. Snyder. Sphalerite also occurs in roadcuts of Pa. Route 869 and combined Routes 36 plus 868.

2. *Location:* A. The main mineralized area is in Bloomfield Township, Bedford County, in the area bounded by Pa. Routes 867 and 868 and a secondary road from Lafayetteville to just south of Maria (Plate 3). The main mineralized area is in Morrison Cove, a valley underlain mainly by Cambro-Ordovician carbonate rocks and bounded by Dunning Mountain on the

northwest, Middle Ridge on the south, and the wooded hills of State Game Lands No. 41 on the northeast. The sphalerite occurrences on Pa. Routes 36 and 868 are in South Woodbury Township.

Mineralization was observed at the following locations:

a) Samuel Snyder shafts 1,110 feet (340 m, measured) east-southeast of Pa. Route 867, 1.2 miles (1.95 km) west of Pa. Route 868, 1.3 miles (2.15 km) east-southeast of the crest of Dunning Mountain, 1.75 miles (2.85 km) northeast of Lafayetteville, and just south of the Jacob J. Snyder - Ira M. Claar property line at an elevation of about 1,440 feet (440 m). The shafts are now filled but, prior to mineral collectors, the area was marked by abundant gossan, breccia, and sulfide minerals in the field (Figure 57).

b) Former prospect (J. J. Snyder, personal commun., 1972) at an elevation of about 1,360 feet (415 m) just (about 100 feet or 30 m?) east and southeast of the Paul Snyder house in a small woods along an east- to northeast-flowing tributary at Potter Creek 0.45 mile (0.75 km) east of Pa. Route 867, 1.25 miles (2.0 km) west of Maria, and 1.6 miles (2.6 km) northeast of Lafayetteville.

c) Mineralized (smithsonite and galena) float boulders on the Ira M. Claar farm at an elevation of about 1,400 feet (425 m) about 1,100 feet (350 m) east of Pa. Route 868, just southwest of an unnamed tributary flowing southeast into a branch of Potter Creek, and 1.88 miles (3.0 km) northeast of Lafayetteville. (Sphalerite in dolomite and chert was also found on the Claar farm about 700 feet (200 m) northeast of the Snyder shafts.)

d) Minor galena and trace sphalerite in small prospect pit at an elevation of about 1,380 feet (420 m) on the northwest side of a small knob whose crest has an elevation of about 1,400 feet (425 m). This pit overlooks a northeast-flowing tributary of Potter Creek, is 1.05 miles (0.65 km) west of Maria, and is 1.85 miles (3.0 km) northeast of Lafayetteville.

e) Sphalerite- and galena-bearing float boulders and outcrop along the east to northeast-flowing branch of Potter Creek and a secondary road between the G. Clause farm and R. C. Smith bridge over Potter Creek. This area is 1,000 feet (300 m) west of the Paul Snyder house, 1,400 feet (425 m) east of Pa. Route 867, and 1.45 miles (2.3 km) northeast of Lafayetteville.

f) Trace sphalerite in an outcrop on the east side of Pa. Route 36, 0.45 mile (0.7 km) north of the Waterside junction with Pa. Route 868. This is about 0.9 mile (1.5 km) south of Keagy Dam at an elevation of 1,200 feet (365 m). Rubble breccia, resembling solution-collapse breccia found prior to mineralization in Tennessee (J. N. Biery, Asarco, personal commun., 1974), is reported to occur on the east side of Pa. Route 36 about 0.9 mile (1.5 km) north of the (Pa. Route 36) Waterside intersection with Pa. Route 868. This is 0.4 mile (0.7 km) south of Keagy Dam and at an elevation of about 1,220 feet (375 m).

Figure 57. View to north of the site of former S. Snyder shafts, Woodbury prospect area, Bedford County. The arrow indicates a scar in the field where corn has been stunted by excess zinc in the soil.

g) Minor sphalerite occurs in an outcrop on the northwest side of Pa. Route 869, 0.4 mile (0.6 km) west of Pa. Route 36 and 432 feet (131 m) east-northeast of the intersection with the old road along Three Springs Run. This location is 1.15 miles (1.85 km) east of New Enterprise and at an elevation of 1,180 feet (360 m). Rubble breccia occurs on the northeast side of the northwest end of a roadcut of Pa. Route 36, 0.7 mile (1.1 km) west of Pa. Route 36 and 0.83 mile (1.4 km) east of New Enterprise.

h) Platt (1881, p. 53) located a trace-sphalerite occurrence as follows: "In a small quarry one mile north of Lafayetteville, the limestone is massive, dark-colored, much specked with quartz and calcite, and with some very small spurs of zinc ore." This trace occurrence was not found, but may be the same area near the sinkhole on the Clause farm where a single grain of galena was found with traces of fluorite (this last, strictly trace occurrence, is neither numbered nor described further).

i) Minor celestine (without observable base metals) occurs in an outcrop on the west side of Pa. Route 867 on the farm of Leo Detwiller. This occurrence is 2,800 feet (860 m) northeast of Lafayetteville at an elevation of about 1,475 feet (455 m).

j) The Scott Smith prospect (Figure 58) is located in Morrison Cove on the south bank of the west headwaters of Potter Creek at an elevation of about 1,400 feet (427 m) and 1,000 feet (300 m) south of Barley Church. The

Figure 58. Geologist stands at the head of a faint scar marking the Scott Smith adit, Woodbury prospect area, Bedford County.

now caved adit is near a hickory tree 350 feet (110 m) east of old Pa. Route 867 over Potter Creek. The ore outcrops in the bed of Potter Creek are 450 feet (140 m) east of the same point. This area is 2.50 miles (4 km) northeast of Lafayetteville and 1.25 miles (2.0 km) south-southwest of the junction of Pa. Routes 867 and 868.

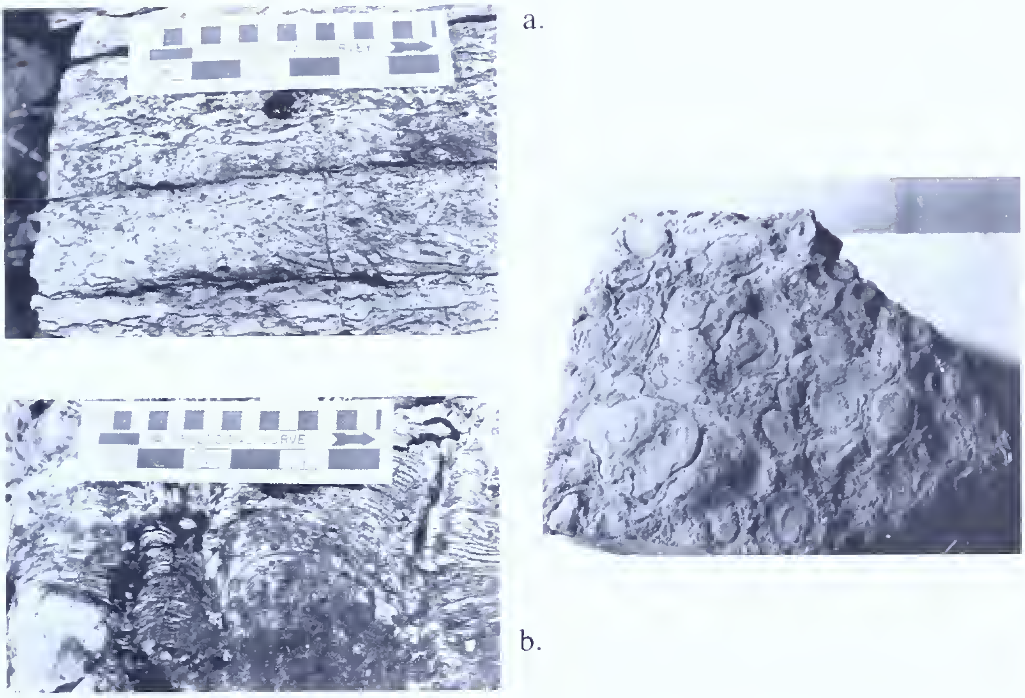
		LATITUDE N	LONGITUDE W
a)	Snyder shafts	40° 13′ 14″	78° 25′ 59″
b)	Former prospect pits	40° 12′ 59″	78° 25′ 54″
c)	Claar float	40° 13′ 21″	78° 25′ 58″
d)	Knob prospect pit	40° 13′ 04″	78° 25′ 39″
e)	Clause outcrops	40° 12′ 58″	78° 26′ 08″
f)	Pa. Route 36 outcrop	40° 11′ 47″	78° 22′ 04″
g)	Pa. Route 869 outcrop	40° 10′ 20″	78° 23′ 14″
h)	Platt's occurrence	Not located	
i)	Detwiller celestine	40° 12′ 27″	78° 26′ 57″
j)	Scott Smith prospect	40° 13′ 53″	78° 25′ 41″

C. TOPOGRAPHIC MAP: New Enterprise 7½-minute quadrangle.

3. *Host Rock:* The state geologic map edited by Gray and Shepps (1960) indicates that the host for occurrences a) through e) and i) is the Cambrian Warrior Formation. Although uncertain because of extreme brecciation and almost no outcrop, the author believes that the following are more likely:

a) Snyder shafts: Dolomite of the middle to upper Bellefonte Formation based on medium-gray color, fine grain size, quartz "eyes" and rare flat-pebble conglomerate, algal stromatolites, and gray chert. The shale partings and laminated character needed for a positive identification are not observed in the available float samples.

b) Former prospect pits: Mines and Gatesburg Formations based on distribution of chert and sandstone float to the south and the presence of galena and sphalerite in a coarse-grained dolomite and galena in sandstone (Gatesburg).



a. b. c.

Figure 59. a. Flat Pebble conglomerate, b. algal stromatolite cross section, and c. algal stromatolite top view, from the Warrior Formation outcrops across the creek from the Ray Snyder farm, Woodbury prospect, Bedford County. The textures suggest a supratidal depositional environment and a reasonable ore host.

c) Claar float: Upper Bellefonte Formation of fine-grained, medium-dark dolomite with gray chert, flat-pebble conglomerate, and pale-blue dolomite veinlets. This host is identical to that for the sphalerite occurrence along Pa. Routes 36 and 164 at Roaring Spring.

d) Knob prospect pit: Lower Warrior Formation based on interbedded dolomite and limestone as well as definite Warrior outcrops to the east (Figure 59a, b and c).

e) Clause outcrops: Dolomite of the Larke Formation based on fine grain size, generally light color, and a Mines-Gatesburg contact mapped to the south on the basis of float.

f) Pa. Route 36 outcrop: Dolomite of the middle to upper Bellefonte Formation based on extrapolation from Spellman's (1966) reference section at Waterside.

g) Pa. Route 869 outcrop: Upper Bellefonte Formation based on excellent dolomite outcrop with gray chert, quartz eyes, etc. This occurrence is 224 feet (69 m) below the Milroy Member of the Loysburg Formation.

h) Platt's occurrence: Limestone of the Trenton Group?

i) Detwiller celestine: Possible dolomite of the upper Bellefonte Formation based on laminated character.

j) Scott Smith prospect: The presence of light to dark-gray finely to coarsely-crystalline dolomite suggests the lower Ordovician Nittany Formation of the Beekmantown Group.

4. *Estimated Total Amounts of Ore Metals:*

A.	<1 g	1-1000 g	1-1000 kg	>1000 kg
a) Snyder shafts				Zn, Pb
b) Former prospect pits		Zn, Pb	Zn, Pb	
c) Claar float		Zn	Pb (low end of range)	
d) Knob prospect pit		Pb, Zn		
e) Clause outcrops			Zn, Pb (low end of range)	
f) Pa. Route 36 outcrop		Zn		
g) Pa. Route 869 outcrop			Zn	
h) Platt's occurrence	Pb?	Zn?		
i) Detwiller celestine		Sr, F		
j) Scott Smith prospect			Pb	Zn

B. ASSAYS: A composite sample from the Snyder shafts of about 100 one-inch chips of limonite with no visible ore minerals was found to contain 3.0% Zn, 1.97% Pb, 5 ppm Co, 30 ppm Ni, 15 ppm Cu, <5 ppm As, and 3.5 ppm Ag. Visual estimates by different geologists of the several tons of float and outcrop in the bed of Potter Creek at the Scott Smith prospect suggest that the grade ranges from 0.5 to nearly 5% Zn. Chips from the upper 140 feet (43 m) of a water well in the Scott Smith area contain 890 ppm Zn and 320 ppm Pb. At least some of the zinc in the chips occurs as highly-fluorescent sphalerite.

5. *Minerals Observed and Relative Amounts:*

A. ECONOMIC

	Major	Minor	Trace
a) Snyder shafts	Sphalerite (early golden-brown and late pale-yellow, the latter fluorescent-apricot under U.V.), smithsonite (earthy, gray mammillary and white	Anglesite (gray rims on galena and white)	Cerussite (white crystals), hydrozincite, sauconite(?)

		Major	Minor	Trace
		crystals), and galena (deformed, coarse-grained in limonite)		
b)	Former prospect pits	Galena, sphalerite (pale-yellow, fluorescent-orange in disseminated chert)	Hemimorphite (clear crystals in vugs), smithsonite	
c)	Claar float		Galena (curved cleavage, apparently from deformation), sphalerite (yellow; some fluorescent-apricot)	Smithsonite (white, mammillary in limonite)
d)	Knob prospect pit		Galena	Sphalerite (trace), hydrozincite
e)	Clause outcrops	Sphalerite (golden-brown with hydrocarbon-like spots in center), galena	Hydrozincite, smithsonite	Anglesite
f)	Pa. Route 36 outcrop		Smithsonite, sphalerite (gray cores with yellow rims)	
g)	Pa. Route 869 outcrop		Sphalerite (light-yellow to grayish in chert; green to red in dolomite)	Smithsonite, hydrozincite

		Major	Minor	Trace
h)	Platt's occurrence (plus Clause)			Sphalerite(?)
i)	Detwiller celestine			
j)	Scott Smith prospect	Sphalerite (mostly orange-brown, some red, bright-red-orange, or almost black)		Galena (thin networks in the breccia matrix with the with the same crystallographic orientation over several inches, and therefore post-tectonic), smithsonite
B.	GANGUE			
a)	Snyder shafts	Calcite (white coarse crystalline in veins), goethite and "limonite"	Pyrite (disseminated in calcite with sphalerite)	Dolomite (gray coarse crystalline in early quartz eyes and white crystals in vugs)
b)	Former prospect pits		Dolomite (white coarse crystalline)	Pyrite, quartz (clear crystals)
c)	Claar float	Dolomite (white coarse crystalline)	"Limonite"	Dolomite (pale-blue coarse crystalline), "black hydrocarbons"
d)	Knob prospect pit	Dolomite (coarse crystalline and crystals)	Calcite	Fluorite (purple in limestone)
e)	Clause outcrops		Dolomite (crystals in vug and coarse crystalline in veinlets)	Pyrite

		Major	Minor	Trace
f)	Pa. Route 36 outcrop	Dolomite (cream to gray coarse crystalline), quartz		"Limonite"(?)
g)	Pa. Route 869 outcrop	Chert (gray, concentric banded nodules)	Dolomite (white coarse crystalline in chert)	Pyrite
h)	Platt's occurrence (plus Clause)	Quartz, calcite		
i)	Detwiller celestine	Calcite, quartz	Celestine[1] (white coarse crystalline), fluorite (purple fading to pink)	
j.	Scott Smith prospect	Dolomite (white coarse crystalline and vein filling)	Pyrite (tiny crystals disseminated in secondary dolomite cementing breccia)	Calcite (white in late, hairline fractures), fluorite (purple).

6. *Paragenesis:* For occurrences a through e: deposition of dolomite rock; formation of quartz plus gray dolomite "eyes"; minor solution thinning resulting in clay-carbon accumulation; white dolomite veinlets; tectonic deformation; dolomite crystals; galena; pyrite; golden-brown sphalerite; calcite; tectonic deformation; light-yellow fluorescent sphalerite, galena(?); and calcite. For the supergene minerals it is known only that the botryoidal geothite formed after anglesite.

For occurrences f and g: deposition of dolomite rock; replacement by dark-gray chert; sphalerite; tectonic deformation; white dolomite in fractures, and bleaching of chert to light gray; smithsonite, and hydrozincite.

For occurrence j: deposition of dolomite rock; light-gray-white dolomite eyes; minor solution thinning resulting in clay-carbon accumulation along stylolites; tectonic brecciation; white dolomite, dark to orange-brown sphalerite, pyrite; galena, bright-orange-red sphalerite, white calcite (Figure 60).

7. *Geologic Description:* The geology of the New Enterprise $7\frac{1}{2}$-minute quadrangle has never been mapped in detail, and is almost certainly

1. Celestine partly verified by a density of 3.95.

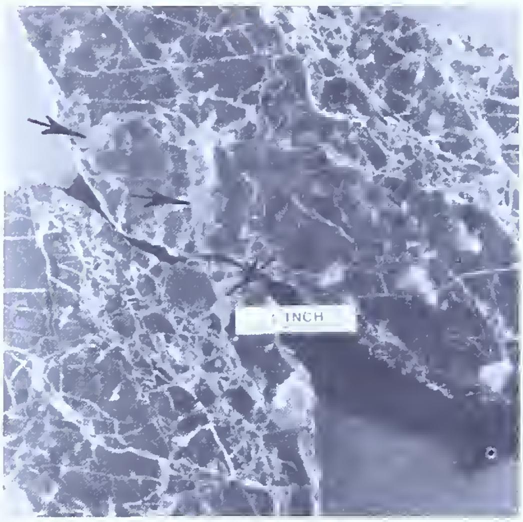


Figure 60. Sphalerite (see arrows) and hypogene dolomite in tectonic fractures cutting earlier clay-carbon stylolites (black, irregular lines), Scott Smith adit area.

more complex than shown on the map of Gray and Shepps (1960). Plate 3, a reconnaissance geologic map of the mineralized areas, shows that the area from the middle Silurian outcrops along the road between Sproul and Ore Hill west of the crest of Dunning Mountain to the Baker Summit thrust fault in the middle Ordovician Trenton Group west of the paralleling Pa. Route 867 is overturned to the west. The overturning has been determined by position of stratigraphic units, crossbedding, intersection of cleavage and bedding, and fossil orientation. In addition to being overturned, the strike of bedding in the Tuscarora and Juniata Formations along Dunning Mountain west of Bakers Summit is not parallel to the crest of the ridge. Segments of the crest appear to have been rotated counter-clockwise along northwest-trending crossfaults or to have advanced different amounts.

A water well drilled in 1974 along the E. Smith-Ellis property line about 100 feet (30 m) east of old Pa. Route 867 (near occurrence j), indicates that pyritic black shale of the Ordovician Antes Formation was encountered at a depth of about 140 feet (43 m). In combination with the surface outcrop of the thrust, this depth yields a dip on the thrust fault of 7° or less to the east-southeast, much shallower than Butts' (1945) map to the north would imply. However, to the west of occurrences a through e, the trace of this thrust appears very linear, suggesting a considerably steeper dip.

East-southeast from the Baker Summit thrust, a rather wide and thoroughly brecciated zone of probable Beekmantown Group dolomites is present. Much of the zinc and lead mineralization occurs in this tectonic breccia. The simplest structural model for this area suggests that the Beekmantown is also overturned, but there is no direct field evidence. From this zone east, the normally dipping Cambrian carbonates and clastics are as approximated on the map of Gray and Shepps (1960). In general, both the Beekmantown Group and Gatesburg Formation have been mapped as War-

rior Formation on previous geological maps. For example, the woods at the south of occurrence b, those northwest of Holsinger Church, and those on the east side of the Ellis-Parsons farm, are probably underlain by Gatesburg Formation.

Because a thickness of 240 ± 25 feet (73 ± 8 m) was measured by the author and by A. M. Thompson (personal commun., 1974) for the Bald Eagle Formation on the west side of the valley at Brumbaugh as compared to 532 feet (162.2 m) measured by Knowles (1966) for the same section at Loysburg Gap, the Bald Eagle Formation of Dunning Mountain may have been tectonically thinned by another thrust. Thompson (1970) has used lithologic rather than color boundaries so changes resulting from post-depositional sedimentary processes are not responsible. Knowles (1966) measured a thickness of 242 feet (74 m) for the lower member of the Bald Eagle Formation at Loysburg Gap. This lower member thickness compares favorably with that of the apparent total thickness of the Bald Eagle at Brumbaugh measured independently by Thompson and the author. Misinterpretation of the upper contact at Brumbaugh by the author is possible, but by Thompson is unlikely. Although the anomalous bedding directions for the Juniata Formation along Dunning Mountain suggest tectonic thinning, it is also possible that many reddish sandstone layers occur in the Bald Eagle Formation of Dunning Mountain as has been observed at Bedford Narrows (Knowles, 1966, p. 23).

The several areas of tectonic breccia aligned roughly north-south and passing through the Scott Smith prospect adit and occurrences c, a, and b may result from the trace of another low-angle, undulatory thrust fault. The wide breccia zone may be part of the linear trace thrust parallel to and west of Pa. Route 867 or a separate splay off the same main thrust. In any event, the breccia zone is nearly 3 miles (5 km) in length and, in places, its surface width is over 1,800 feet (550 m). Mineralization may be confined to the areas of greater displacement and is usually richest (up to about 50% sphalerite in hand-size samples) where brecciation is most intense. Mineralization has not been observed near the north or south ends of the observed thrust.

As first suggested by Wilson (1952, Figure 2), an east-west cross fault may pass through the area of occurrence b. This fault occurs approximately along latitude 40° 12′ 54″ N with the south side apparently displaced downward relative to the north, based on displacement of Gatesburg near Maria. Displacement may decrease to the west. South of this fault, the major structure traced by the Gatesburg Formation is an asymmetrical, southwest plunging anticline with an overturned west limb. In disagreement with the reconnaissance map of Wilson, the writer believes that Warrior Formation is exposed in the core of the anticline, as for example the outcrops 1,800 feet (550 m) southeast of occurrence b. Between Pa. Route 867 and the over-

turned west limb of the anticline traced by the Gatesburg, at least the middle of the Beekmantown Group may have been removed by thrusting. Only float from the Mines and Bellefonte Formations has been recognized.

Occurrence b is on the intersection of the undulatory mineralized thrust with the cross fault at 40° 12′ 54″ N latitude. The possible presence of additional mineralization along the cross fault in the area of the Glasgow farm to the south and southeast of occurrence b might be tested by drilling deep angle holes to cross the 40° 12′ 54″ fault.

The geology of the carbonate valley from the cross fault at 40° 12′ 54″ N to the village of Bakers Summit appears to consist of right-side-up Warrior limestone on the east and brecciated Bellefonte dolomite on the west. This latter area is almost devoid of outcrops and could contain other formations. If the dolomitic limestone outcrops along Pa. Route 867 west of occurrences a and e are the Milroy Member of the Loysburg as suspected, then both the Bellefonte and Loysburg Formations may be overturned. Variable directions of bedding in the Loysburg and the lack of a good outcrop of Bellefonte prevent more certain conclusions.

Limestone of the Axemann Formation of the Beekmantown Group has not been observed in the area of the Woodbury prospects. Butts (1945) found that it pinched out 4½ miles (7 km) north of the New Enterprise quadrangle. Spelman (1966) found thick Axemann at his Waterside section on the east side of the New Enterprise quadrangle. When the Axemann Formation is absent, very coarsely crystalline dolomite occurs at the same horizon (Lees, 1967). The rare, extremely coarsely crystalline dolomite rock at the Scott Smith adit may be dolomitized Axemann.

In the east Tennessee district, zinc ores occur in brecciated carbonates formed by solution collapse formed during periods when unconformities were developing (Hoagland, 1971). The only observed unconformity in this region was within rather than above, the Beekmantown Group. This was in Spelman's (1966) reference section No. 9 at Williamsburg, Blair County. Here a thin limy shale zone occurs in a possible erosional unconformity at about the Larke-Nittany contact.

Chafetz (1969) and other geologists have sought, but not found, an unconformity at the top of the Bellefonte Formation. In central Pennsylvania there is no unconformity between Chazyan and Canadian carbonates, i.e., between the Bellefonte and Loysburg Formations. The only described unconformity is much younger, between the Trentonian and Black River, i.e., at the base of the Nealmont Formation (Thompson, 1963). Rocks of Black River and Chazyan age are missing in the area of Friedensville zinc ore body in the Lehigh Valley. Thus, the period of nondeposition began earlier in the Lehigh Valley. However, geologically significant periods of time may not be required to produce collapse breccia suitable as a host for zinc ore. Indeed, collapse breccias do occur throughout the Beekmantown Group of central

Pennsylvania despite apparent continuous deposition until the end of Black River time. At present, it also cannot be ruled out that the collapse breccias represent dolomitizing or spent metal-bearing hydrothermal solutions.

Plate 3 presents data for "total" zinc and lead in stream sediments. In general, correlation with the known occurrences is good, and indeed some of the occurrences were found by carefully searching areas upstream from anomalies. Based on histograms of lead and zinc data for the initial, relatively unbiased sampling for this area, zinc values $\geqslant$200 ppm and lead values $\geqslant$70 ppm are anomalous. The respective medians are 110 and 30 ppm. Anomalies unrelated to known occurrences, and therefore untested, are located: about 1,000 feet (300 m) east-southeast of occurrence b, about 4,000 feet (1,200 m) northeast of occurrence b, and about 1,000 feet (300 m) north of Barley Church. This latter probably results from a similar situation to that at Potter Creek at the Scott Smith prospect. There, all but the base of the thrust has been removed by erosion. Also, the anomaly in the headwaters of Potter Creek beginning at the Scott Smith adit is much too persistent to result from a single point source.[2] Additional mineralization occurring as leakage above the main thrust seems possible. Compare this anomaly, for example, with the rapid decay of the anomaly downstream for occurrence b. Therefore, exploration up to a mile east of the Scott Smith prospect may be warranted. Assuming a 7° dip on a planar thrust, the depth to the thrust would be only about 400 feet (125 m) beneath Pa. Route 868 east of the prospect. If the section is overturned in this area, mineralization (if any) east of the Scott Smith adit could occur in collapse breccia in interbedded limestone and dolomite at the horizon where the Axemann should occur. Mineralization at occurrence b and to the east could be localized by a sizable breccia zone resulting from intersection of two major faults.

Literature on the Woodbury prospects is sparse. The available information is quoted in its entirety below:

> S. Snyder's farm, three miles west from Woodberry, Bedford County. Surface ore. Metallic lead 25.80% and Metallic zinc 32.97 (McCreath, 1879, p. 280.)
>
> In a quarry one mile north of Lafayetteville the limestone is massive, dark colored, much specked with quartz and calcite, and with some very small spurs of zinc ore (Platt, 1881, p. 53).

Occurrence a) on the Jacob Snyder farm consisted of two shafts about 25 feet (8 m) apart. Both the 75-foot (23 m) eastern and 50-foot (15 m) western shafts were dug by Samuel S. Snyder (Jacob Snyder, personal commun., 1972). The area of these shafts is now a 25 × 60-foot (8 × 19 m) gossan scar where corn becomes thoroughly stunted (Figure 57). The former prospect pits in the area of occurrence b were also probably dug by Samuel S. Snyder.

2. Scott Tregaskis, graduate student at The Pennsylvania State University, (personal commun., 1976) reports sphalerite in outcrops to the east of the Scott Smith mine.

The quarry (occurrence h of this report) referred to by Platt as 1 mile north of Lafayetteville is probably the one most recently worked by Harry (Skip) Snowberger.

The Scott Smith prospect (described as an adit but caved in) has been named after the man who did the mining and died prematurely from an accidental explosion in the adit (Moreta Barley, personal commun., 1973). Scott Smith, 1858-1889, died in the home of Samuel S. Snyder, then owner of other zinc-lead prospects. Scott Smith was considerably outlived by his widow, Ellen, 1860-1924 (Figure 61). The adit was relocated by geochemical stream sediment sampling and discussions with Ira M. Claar and Elwood Smith, residents of the area.

Tradition states that Thomas Croyle, a pioneer blacksmith of Bedford County, was able to mine lead "a half-day's journey" from Mile Level. Generally, it is assumed that the mining was done in Snake Spring Valley (formerly Croyle's Cove), but the Woodbury prospects are another possibility (David Kohler, personal commun., 1973).

In summary, the observed zinc-lead occurrences, geochemical data, wide thrust faults and collapse breccias in lower Ordovician rocks all suggest that further evaluation of the New Enterprise-Roaring Spring-Henrietta area is warranted. A few outcrops in Potter Creek (100 feet or 30 m east-northeast of the Scott Smith prospect) are of ore grade, and it seems possible that a sufficient volume of gently-dipping mineralized tectonic breccia could be found to constitute an ore body. The overall favorable area is also covered by the Roaring Spring area and Soister mine reports (p. 115 and p. 120).

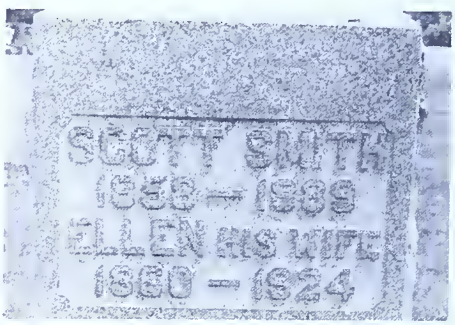


Figure 61. Headstone of Scott Smith, early lead prospector, killed in an accidental explosion underground at the prospect that now bears his name (Moretta Barley, personal commun., 1972).

SILURIAN (TONOLOWAY AND KEYSER FORMATIONS) OCCURRENCES

26. ALMEDIA MINE AREA, COLUMBIA COUNTY

(Former Lead-Zinc Producer With Potential Small Reserves)

1. *Name:* The Almedia mine hoist shaft area is reported to be owned by Fred Sharrets, and the Webb mine and mineralized outcrops to the west owned by James McElrath.

2. *Location:* A. The Almedia mine area is located 0.6 mile (0.95 km) north of the Susquehanna River, 0.05 mile (0.05 km) west of the South Centre-Scott township line, and 3.95 miles (4.8 km) due east of the summit of Turkey Hill, Scott Township, Columbia County. The Webb mine(?) may be located in the south face of the bank 625 feet (190 m) southwest of the Almedia mine and about 325 feet (100 m) northwest of the northwest edge of U. S. Route 11 (Figure 62). Mineralization also occurs in the outcrops behind Dave's Seafood, about 250 feet (76 m) east of the center of Bissetts Lane and 150 feet (46 m) north of U. S. Route 11.

B.

	Almedia Mine Hoist Shaft	Webb Mine(?) Adit Entrance	Dave's Seafood Outcrops
LATITUDE N:	41° 01′12″	41° 01′09″	41° 01′11″
LONGITUDE W:	76° 23′14″	76° 23′20″	76° 23′05″

C. TOPOGRAPHIC MAP: Bloomsburg $7\frac{1}{2}$-minute quadrangle.

3. *Host Rock:* Upper Tonoloway Formation limestone of upper Silurian age. Most of the Upper Tonoloway is a shaly limestone (with hypersaline features to the west, Figure 63), but mineralization is localized in the more competent limestone beds. Zinc-lead mineralization has also been reported to be present in limestones of the Keyser Formation in the area.

4. *Estimated Total Amounts of Ore Metals:*

A. <1 g:

1-1000 g:

1-1000 kg: Cu, As, and Ag[1]

>1000 kg: Pb, Zn

B. ASSAYS: (Earl, 1950a, p. 3)

Good core logs by P. K. Sims and P. E. Hotz, U. S. Geological Survey, (Earl, 1950a) indicate unassayed mineralization in DDH No. 1 at 57.8–58.8 feet (17.6-17.9 m), 78.3 feet (23.9 m), 136.9 feet (41.7 m), 139.9-141.5 feet (42.6-43.1 m), 147.0-147.6 feet (44.8-45.0 m), 166.2 feet (50.7 m), and 170.8 feet (52.1 m).

1. Stephenson (1947) reports claims by G. Bronson and K. Kline, the 1947-vintage promoters, that the galena produced around 1900 was high in silver. The silver content has not been verified.

Figure 62. Webb(?) adit entrance in shaly limestone of the Tonoloway Formation, 625 feet (190 m) southwest of the Almedia mine.

DDH No.	Intercept		Core Recovery	Assays	
	Feet	Meters	%	Pb %	Zn %
1	34.2— 38.4	(10.4—11.7)	62	1.3	4.1
1	81.0— 82.7	(24.7—25.2)	85	.3	10.8
1	137.7—139.8	(42.0—42.6)	55	.2	35.6
1	148.6—150.7	(45.3—45.9)	45	.3	21.4
1	165.2—165.7	(50.4—50.5)	66	1.8	39.3
1	170.8—178.3	(52.0—54.3)	40	3.8	14.5
2	43.0— 43.8	(13.1—13.4)	100	10.8	18.3
2	44.6— 45.1	(13.6—13.7)	100	.4	.7
2	70.3— 75.2	(21.4—22.9)	86	2.7	6.6

5. *Minerals Observed and Relative Amounts:*

A. ECONOMIC

Major:	Galena, sphalerite (light-yellow to brown to ruby-brown)
Minor:	Cerussite, smithsonite (yellowish-gray)
Trace:	Anglesite, secondary, unknown Cu mins., pyrite, sauconite(?), hydrozincite, tennantite*

B. GANGUE

Major:	Calcite, dolomite (coarse crystalline)
Minor:	
Trace:	Quartz

6. *Paragenesis:* Limestone with disseminated pyrite, coarse dolomite replacing limestone, pyrite, fibrous and cleavage calcite, sphalerite (brown and reddish) and galena replacing dolomite, tennantite and sphalerite (honey), deformation, quartz, calcite, and trace fluorite. Some quartz may also be contemporaneous with the dolomite.

7. *Geologic Description:* The mine area is located on the south limb of the Berwick anticline, similar to the Faylor quarry Zn-Pb occurrence at Winfield, Union County.

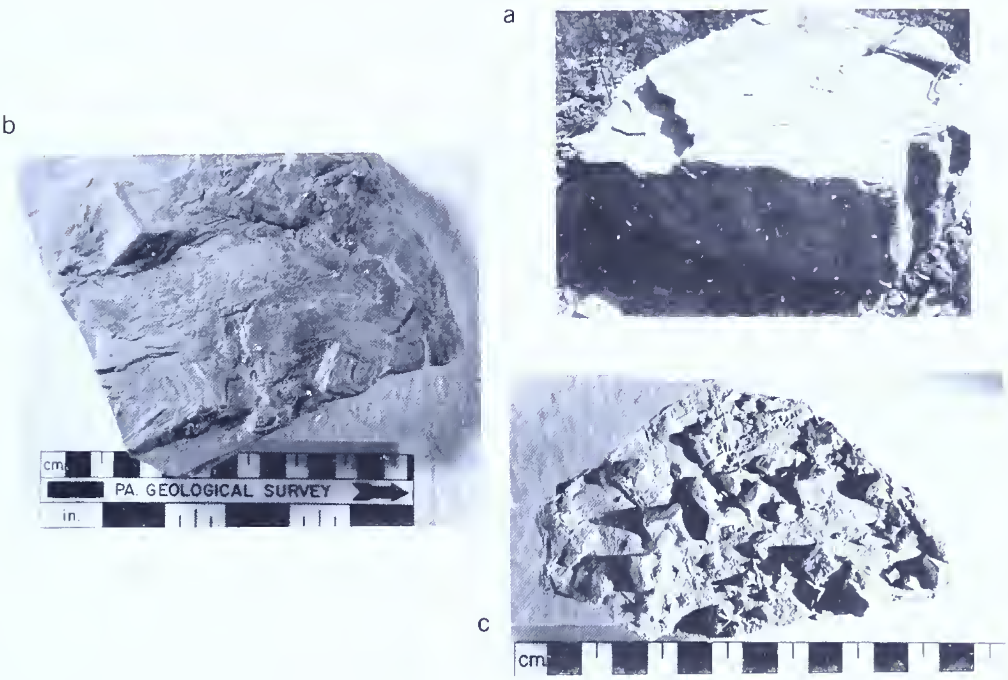


Figure 63. Mudcracks (a) and salt casts (b, c) in Tonoloway Formation of Blair County. These features suggest a hypersaline, arid depositional environment and possible source of chloride-rich ore metal transporting solutions. Algal laminae in the same samples suggest a possible organic reducing agent to localize the deposition of metals.

At the mineralized outcrop (Plate 4), the attitude of bedding is N71E and 42S. At this outcrop, a 6-inch- (15 cm) wide galena and sphalerite vein strikes N75E and dips approximately 75N. Narrower calcite veins with sphalerite and galena in the same outcrop are nearly parallel. To the southwest of this same outcrop, there is a 1-to 2-foot (30-60 cm) wide vein composed of pure, coarse white calcite cleavages. This vein, which is partly exposed for 75 ± 10 feet (23 ± 3 m), strikes N64E and is approximately vertical. It is barren of sulfides. D. M. Hoskins (personal commun., 1972) postulates that a strike fault (i.e., parallel to strike but not to bedding) passes through the area southwest of the mineralized outcrop. This has increased the apparent thickness of the Tonoloway (at the expense of the Keyser Formation) in the area south and southwest of the mine.

Earl (1950a) in a U. S. Bureau of Mines report states that the ore occurs in a northeast fracture zone along the strike of the limestone and dips steeply to the southeast. Earl's observations were made after both drilling and dewatering of the mine to 44 feet (14 m), and should be considered. As noted, the best reported ore intercept consisted of 7.5 feet (2.3 m) of 3.8% Pb and 14.5% Zn. Assays of some additional footages of cores 1 and 2

and the drilling of a new hole approximately 100 feet (30 m) east of hole 1 appears warranted to evaluate the potential of this mine. A. V. Heyl (personal commun., 1972), P. E. Hotz (personal commun. to Heyl, 1960), and the author believe that the ore potential of the Almedia mine area may have been underestimated. Indeed, if inclined drill hole number 4 deviated a mere 5°, it would have reached 236 rather than 260 feet (71-79 m) in a horizontal direction and fallen 24 feet (7 m) short of the old workings (Figure 64).[2] Stephenson (1947) stated that the ore zone was somewhat over 100 feet (30 m) thick perpendicular to bedding, and of unknown length along strike. He reported that ore distribution was very spotty and occurred as irregular replacements of limestone and along joint planes. Stephenson reports a production by the Almedia Lead and Zinc Mining Co. for the approximate period 1900-1903 of 900 tons of lead and zinc ore and 180 tons of pure galena. Earl (1950a, p. 2) reports 1,900 tons of ore resulting in the shipment of $110,000 worth of concentrates. Together, these data yield a concentrate value of $610/ton. Operations ceased when a miner was killed in the hoist bucket.

Paul Herbert, Jr., geologist for Goldfields American, examined the property in about 1953 and suggested that the main ore body is a crackle-breccia of lenticular shape associated with gash veins and replacements, which is elongated parallel to the trend of the limestones. He believed that the body is formed along and above a possible thrust fault or fault intersection (Paul Herbert, Jr. to A. V. Heyl, personal commun., 1953).

A. H. Hess (personal commun., 3/18/73) described the Almedia mine workings as follows: The hoist shaft was 110 feet (34 m) deep with man ladders on the west side; 38 feet (12 m) from the surface, there was rich galena ore in the north side of the shaft; at 40 feet (12 m) a horizontal drift trended southwest (through which ore was never removed) to a second vertical shaft; also, at about 40 feet (12 m), a horizontal stope ran northeast 75 feet (22.8 m) toward Bissetts Lane; this stope was 10-12 feet (3-4 m) high and 12 feet (4 m) wide. Hess also reports efforts by several major companies to lease the property in the 1950's, but no mutually satisfactory agreement was ever reached. The Arthur Sorbers drill hole was reported to have encountered good ore about 1933.

Smith (1967), using stream sediment geochemistry, located other zinc-lead, and possibly silver, anomalies in the region, but did not pursue the results.

Lenker (1962) analyzed sphalerite from the Almedia mine area by emission spectroscopy. The sphalerite contains 2000 ppm Cu, 600 ppm Cd, 190 ppm Ge, and 35 ppm Mn. Secondary copper minerals observed during the present study occur on weathered sphalerite surfaces.

2. If A. V. Heyl's location for the Webb mine is correct, then all of the holes failed to completely test the ore zone (A. V. Heyl, personal commun., 1976).

Figure 64. U. S. Bureau of Mines angle diamond drill hole number 4, the most useful because of its artesian nature. Used as a routine domestic supply and following the Agnes flood in 1972 as an emergency public supply.

The Webb mine of Cleaveland (1816), may be the adit located at the base of the hill about 650 feet (200 m) southwest of the hoist shaft. However, Arthur H. Hess (personal commun., 3/18/73) reports that this adit was dug around 1900, that it went back in an arc for about 100 feet (30 m) on a 20° grade, that it was barren, and that the wall rock was "yellow-green." Near the entrance, however, the author observed normal buff-colored, shaly Tonoloway limestone in the walls of the N29W-trending adit (Figure 62). A. V. Heyl (personal commun., 1972) believes that the Webb mine may be a concealed incline or adit at the base of the hill about 150 feet (46 m) northwest of the hoist shaft. His placing the location here is partly based on his assessment of the dumps northwest of the Almedia mine.

Miller (1934, p. 321) reports that calcite veins with galena, sphalerite, and pyrite were common in what are now termed the Tonoloway and Keyser Formations of Columbia County. Frank Baker's (later Robert Baker's) quarry, 1.9 miles (3.0 km) along strike to the northeast, was reported to have yielded much galena and sphalerite at times (Miller, 1934, p. 323). However, neither sphalerite nor galena were observed in this quarry, about 0.6 mile (1 km) northwest of Lime Ridge, during the present study. A. H. Hess (personal commun., 3/18/73) also reported that sphalerite with little galena was obtained from a township quarry dug about 1950-1955 for road fill. Hess reported that this quarry (=Dave's Seafood outcrop) yielded sizable masses containing approximately 60% sphalerite.

A. H. Hess reported that a quarry 0.9 mile (1.4 km) southwest of the Almedia mine also produced some good lead and zinc ore.[3] The rock in the quarry is highly fossiliferous near the top, slickensided, extremely brecciated and healed with fetid white calcite, but unmineralized. A possible small crossfold with north-south axis appears to plunge to the south. A 6 × 6-foot (2 × 2-m) slickensided surface with vertical striae and very

3. This quarry, now reported to be owned by an attorney Hummel (formerly C. Neufer estate?), appears to be located in the Keyser Formation, rather than the Wills Creek as required by projecting from a borrow pit 0.65 mile (1 km) southwest of the Almedia mine in lower Tonoloway shaly limestone with salt casts and a median bedding of N83E, 38S. Barren pink calcite plus quartz veins up to 10 inches (26 cm) thick in the borrow pit trend about N52E, 58NW.

abundant secondary white calcite trends approximately N35E, 75E. This quarry may be the Herbert Hoffman quarry of Miller (1925b), p. 213. Miller described this quarry as being northeast of Espy and "Where the pure vein calcite is found it is usually accompanied by sizable lumps of sphalerite and galena. . . . An old adit leading to the galena and sphalerite workings was in poor condition and did not permit an examination of the rocks below the surface." This old adit could also be the Webb mine.

The available data suggest that additional exploration in the vicinity is definitely warranted. This should include, but not be limited to: 1) a detailed geologic map and, where possible, B-zone soil survey for lead, zinc, copper, silver, and mercury over the Tonoloway and Keyser from the Bloomsburg to the Berwick city boundaries. This will, however, be difficult because of development, river colluvium, and swamps. 2) Stream sediment reconnaissance for the same elements over the Upper Silurian and Lower Devonian rocks of the Berwick anticline. Water samples should be analyzed for total heavy metals. 3) Core drilling to define the southeast plunge(?) of the ore from the Almedia mine. U. S. Bureau of Mines drilling is open-ended to the south and east.

27. CANOE CREEK QUARRY, BLAIR COUNTY

(Trace Zinc Occurrence)

1. *Name:* New Enterprise Stone and Lime Co., Inc. quarry at Canoe Creek.

2. *Location:* A. An old, upper level (approximate elevation 1200 feet, or 365 m) of an active limestone quarry located 1.4 miles (2.1 km) northwest of the junction of New Creek and the Frankstown Branch of the Juniata River. This part of the quarry is 0.4 mile (0.7 km) north-northeast of a benchmark at 970 feet (295.6 m) in Turkey Valley. The quarry is on the northeast side of a gap through the ridge which bounds Turkey Valley on its northwest side, Frankstown Township, Blair County.

B. LATITUDE N: 40° 29′ 11″ LONGITUDE W: 78° 17′ 48″

C. TOPOGRAPHIC MAP: Frankstown $7\frac{1}{2}$-minute quadrangle.

3. *Host Rock:* The sphalerite occurs in limestone of the Lower Devonian upper Keyser Formation, 25 ± 10 feet (8 ± 3 m) below the cherty limestone (Corriganville Member?) of the Old Port Formation.

4. *Estimated Total Amounts of Ore Metals:*

$<$1 g:
1-1000 g: Zn
1-1000 kg:
$>$1000 kg:

5. *Minerals Observed and Relative Amounts:*

A. ECONOMIC

Major:

Minor: Sphalerite (orange-brown)
Trace:

B. GANGUE

Major: Calcite (white, crystalline, saccharoidal)
Minor: Dolomite (pink)
Trace: Quartz, pyrite (not spatially associated with sphalerite). No fluorite on the mineralized joint, but observed elsewhere on this level of the quarry.

6. *Paragenesis:* Organic accumulation (fossils then clay-carbon insoluble residue on stylolites and slickensides), white calcite veins, pink dolomite and sphalerite.

7. *Geologic Description:* This occurrence, found by Tim Troutman and John H. Way of the Pennsylvania Geological Survey, occurs on the northwest limb of a gentle syncline.

At the Canoe Creek quarry, most of the upper Keyser is tan and buff limestone with clayey interbeds. The top of the Keyser is a dolomite bed. The beds most closely associated with mineralization are micritic limestone with skeletal fragments of small brachiopods, ostracods, and scarce corals. Except for fossils, the upper part of the Keyser resembles the Tonoloway Formation exposed in the main (lower) level near the northwest edge of the quarry. It is also similar to the top 10 feet (3 m) of the Keyser Formation at the Altoona Bible Church (Allegheny Furnace measured section) at Altoona, approximately 6 miles (10 km) to the northwest (J. H. Way, personal commun., 1973). At the Altoona Bible Church section, Way determined that the Keyser Formation was 109 feet (33 m) thick. Of this, the top 10 feet (3 m) is laminated, shaly limestone.

The Old Port Formation at the very top of the quarry contains well-preserved brachiopods and other fossils.

Mineralization occurs on a joint which is not very planar, but in general trends N45E, 73NW. The attitude of bedding near the sphalerite is N57E, 16SE. The joint trend is thus subparallel to the strike of bedding and subnormal to the dip of bedding. This mineralized joint is not part of a pronounced set as when compared to the joints at the New Paris fluorite occurrence near Bedford (Smith and Way, 1973), but is at the same stratigraphic horizon. Where concentrated, sphalerite occurs on the joint as ¼ to ½ inch (0.6 to 1.3 cm) grains spaced approximately 1 foot (30 cm) apart. Deposition of sphalerite grains appears to have been controlled by extremely localized reducing zones of organic origin because it is concentrated adjacent to clay-carbon residues on slickensides or stylolites, or corals that contain hydrocarbon-like black areas.

This occurrence is of no direct economic importance, but further documents the occurrence of zinc mineralization in the upper Keyser Formation. This portion of the Keyser is lithologically similar to the Tonoloway Formation which elsewhere contains sphalerite, suggesting that the lithology

of the host is a more important control than age. Within 20 miles (32 km) of this occurrence, trace zinc-lead mineralization occurs in host rocks ranging from early Ordovician to late Devonian in age. This suggests that hydrothermal mineralization (not necessarily of magmatic origin) was both widespread and of post-late Devonian age.

28. DOUGHTY MINE, NORTHUMBERLAND COUNTY

(Former Small Lead-Zinc Producer)

1. *Name:* Doughty mine, or possibly, ". . . Mr. Dougherty of Shamokin['s] . . ." mine (Lesley, 1892, p. 962).

2. *Location:* A. The main Doughty mine workings are located at an elevation of 675 ± 50 feet (206 ± 15 m), 1.35 miles (2.2 km) south-southwest of the junction of Shamokin Creek with the Susquehanna River and 1.25 miles (2.0 km) northeast of the junction of Sealholtz Run with the Susquehanna, Upper Augusta Township, Northumberland County (see Figure 65). This location is 1425 feet (440 m) to the southwest of railroad milepost 136 (not 135 as reported by Lesley, 1892 and Miller, 1924). The small horizontal adit a few feet above railroad level is 825 feet (251 m) northeast of the intersection of the projection of the main workings entrance across the railroad.

B.	LATITUDE N	LONGITUDE W
Main workings	40° 49′ 30″	76° 49′ 12″
Horizontal adit	40° 49′ 38″	76° 49′ 08″

C. TOPOGRAPHIC MAP: Sunbury 7½-minute quadrangle.

3. *Host Rock:* The host rock is limestone of the Silurian Tonoloway Formation (Smith, 1972b). D. M. Hoskins (personal commun., 1972) believes that all workings are 150 ± 25 feet (46 ± 8 m) below the Keyser Formation. Although the Keyser-Tonoloway contact is exposed along the railroad, minor folds and incomplete outcrop prevent precise correlation. Johnson (1844, p. 44) reported that the beds overlying the limestone in which the lead is found contain orthoceratities, encrinites, producti and Juglandites fossils.

White (1883, p. 92) described the base (from bottom up) of the "Bossardville"[1] as follows: "15. Limestone, bluish black, quite pure 12′ [3.7 m], 14. Limy shales; — horizon of Lead and Zinc ores, 3′ [0.9 m], 13. Dark blue, limestone, pure, 8′ [2.4 m], 12. Shaly limestone, and limy shales, 35′ [11 m]." The author believes that White's ore horizon is actually a relatively unmineralized easily-excavated horizon used for access to ore in the adjacent limestones. It is believed that the ore is mostly in unit 13 of White.

1. Now Tonoloway Formation in this portion of southeastern Pennsylvania.

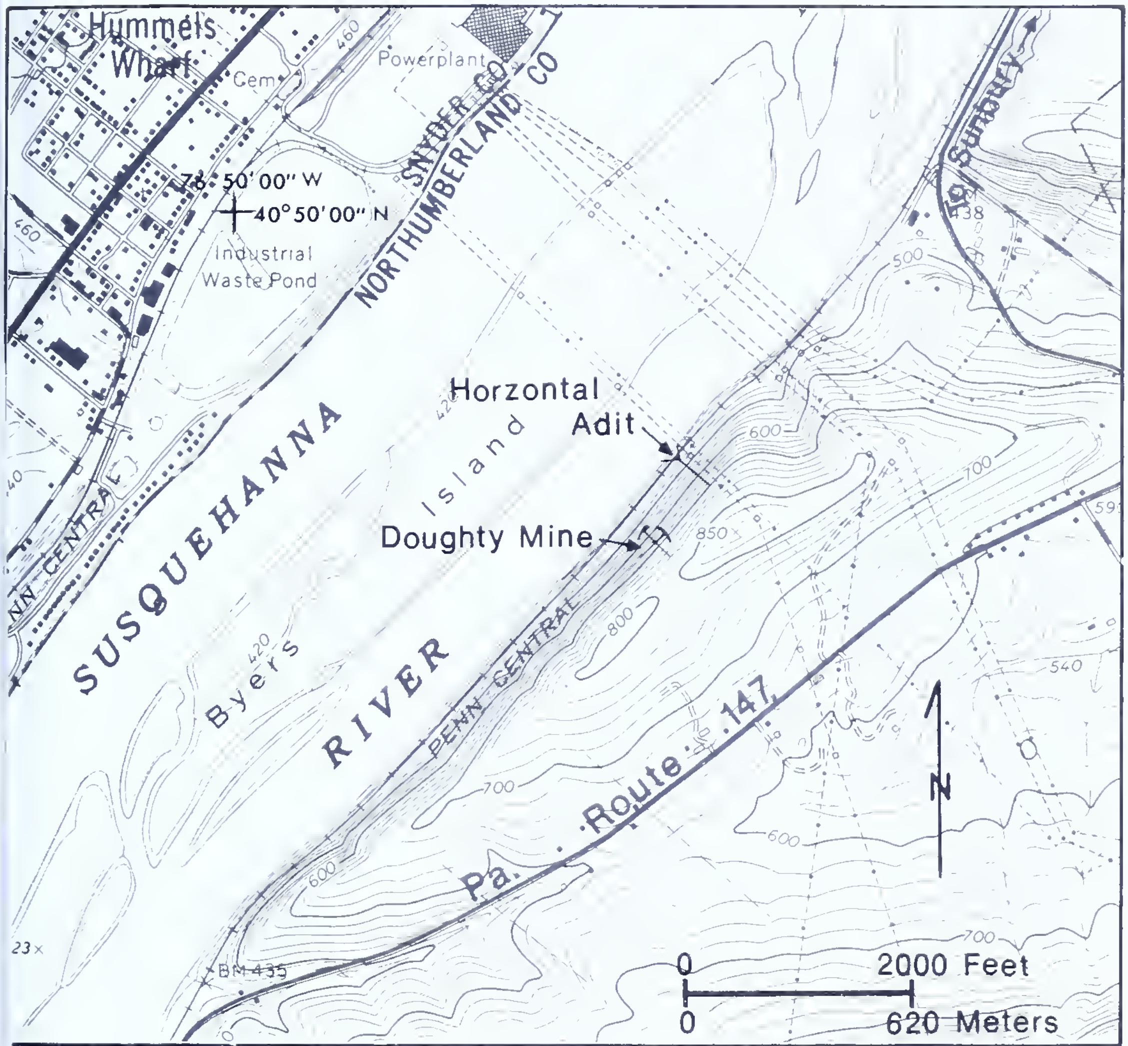


Figure 65. Location of the Doughty Mine, Northumberland Co.

4. *Estimated Total Amounts of Ore Metals:*
   <1 g: As
   1-1000 g: Cu
   1-1000 kg:
   >1000 kg: Zn and Pb
5. *Minerals Observed and Relative Amounts:*

A. ECONOMIC

Major:	Hemimorphite,* galena
Minor:	Anglesite, cerussite* (some twin microcrystals), smithsonite*
Trace:	Sphalerite (yellow to golden), chalcopyrite, hydrozincite, pyrite (pyritohedrons), aurichalcite*

B. GANGUE

Major:	Calcite (scalenohedrons with outer zone fluorescent red)
Minor:	Fluorite (light-purple from outcrop just southwest of mine entrance and "chimney," but not with ore proper),[2] sauconite(?),[3] dolomite, quartz
Trace:	

6. *Paragenesis:* Calcite, galena and sphalerite, calcite and dolomite. The hemimorphite, cerussite, etc. are obviously supergene minerals, but their paragenesis has not been determined.

7. *Geologic Description:* The mineralized area is located near the crest of the Selinsgrove Arch, a gentle anticline. The main mine is developed in a second-order anticlinal fold on the approximate crest of the arch. This fold, which plunges to the east at approximately 10°, results in dips of up to 40° within the mine (see Plate 4).

The 5-foot- (1.5 m) deep hole (excluding partial backfilling) shown in the floor of the irregular, east-southeast drift on the lower level was developed on a probable kink band which terminates in plastically-deformed limy shale. Secondary calcite crystals have developed in the crumpled shale but sulfides were not observed here. A few small kink bands and tight minor folds occur in the outcrops to the northeast. One such fold, which occurs 85 feet (26 m) northeast of the present mine entrance and trends N80E, has a similar core of crumpled limy shale, but with fluorite-bearing gash veins in the more competent beds and no sulfides. The core of this fold was prospected with a very short adit as shown in Figure 65.

Whenever possible, the main mine workings were developed in two 3-foot- (0.9 m) thick limy shale beds [separated by 8 feet (2.4 m) or more of limestone]. The limy shale beds appear to have been chosen because they can be readily excavated with a pick. Two connections between the shale beds were developed in ore. Approximately 850 feet (260 m) of drifts were observed during the present study. The height of the drifts varies from less than 2 feet (0.6 m) to more than 8 feet (2.4 m), but the average height is probably 4 feet (1.2 m). Several areas of limestone dry wall (Figure 66) and shaly back-filling on the lower level suggest that former workings were more extensive. This is also indicated by the presence of traces of rotted wooden ties in the floor of the main railroad haulage caved-in at the west end (Figure 67), suggesting the existence of a former track bed to the outcrop. It would have been difficult, if not im-

2. Trace to minor amounts of purple fluorite are widespread in the Tonoloway Formation, but may be unrelated to zinc mineralization.
3. This mineral, closely associated with hemimorphite, was found by J. H. Barnes to yield a smectite group X-ray diffraction pattern.

Figure 66. Drywall support-backfilling method on the lower level of Doughty mine. The roof is a bedding surface.

Figure 67. Caved-in area of "railroad haulage," Doughty mine, Sunbury area, Northumberland County. At present, the mine is unsafe.

possible, to transport materials and waste through the present entrance (Figure 68).

The hole in the floor of the railroad haulage is over 10 feet (3 m) deep. This hole is partly natural, but was developed further on a barren calcite vein following a joint. Additional, partly natural, cave-like openings occur at the narrow right angle bend connecting the "20-foot vein" drift with the "railroad" haulage.

Although traces of galena and/or hemimorphite are present in many of the subvertical calcite veins in the main mine workings, only three areas of significant mineralization were observed. The insignificant calcite veins generally have a pronounced N-S trend. On the other hand, two significant mineralized veins and the mineralized replacement bed all trend NW-SE. Both barren and mineralized calcite veins generally refract and pinch out shortly after entering the upper, shaly limestone bed. Calcite veins above the upper shaly limestone bed are again vertical and trend north-south. Although only exposed in the "chimney" (Plate 4b) in the mine proper, these veins were observed to contain traces of fluorite but no sulfides in the dark-blue limestone above the upper shaly bed. This is the same dark-blue limestone bed which contains fluorite in calcite veins at the outcrop just southwest and 85 feet (26 m) northeast of the present mine entrance. All of the significant mineralization observed during the present study occurs in the middle, 8- to 12-foot (2.4 to 3.7 m) thick limestone bed sandwiched between the upper and lower shaly limestone beds.

Figure 68. Present entrance to the Doughty mine, Sunbury area, Northumberland County.

The so-called "20-foot vein" has both replacement and vein-like features. This vein is about 20 feet (6 m) long and is exposed in a small NW-SE trending drift on the upper level. Where vein-like, it is mostly calcite, essentially vertical, and 4-6 inches (10-15 cm) wide with galena concentrated on the southwest side of the vein. The vein-like portion is exposed in a 15-inch (38 cm) wide, 2-foot (60 cm) deep and 6-foot (1.8 m) long trench in the floor. Farther northwest, replacement features predominate with considerable hemimorphite-rich gossan in limestone. At the "T" (see Plate 4b and Figure 69) junction with another drift, nearly barren calcite veins again reappear.

The "main floor vein" (Figure 70) was observed to be mineralized for over 40 feet (12 m) and is still ore-bearing as far as it can be observed to the northwest. Where it is best exposed, it is vertical. Its strike, however, follows that of adjacent bedding, i.e., it strikes N6W on its south end, but curves to N21W at its last exposure to the northwest. This vein is 1-2 feet (30-60 cm) wide and contains rich oxidized ore with abundant hemimorphite, galena, and secondary lead minerals. It has been mined out over a length of approximately 20 feet (6 m), leaving a hole with a depth of 10 feet (3 m) and a width of 5 feet (1.5 m) connecting the upper and lower levels.

Figure 69. Intersection of "railroad haulage" and incline from upper level of Doughty mine showing workings in limy shale and roof of thicker-bedded limestone to left of geologist's head.

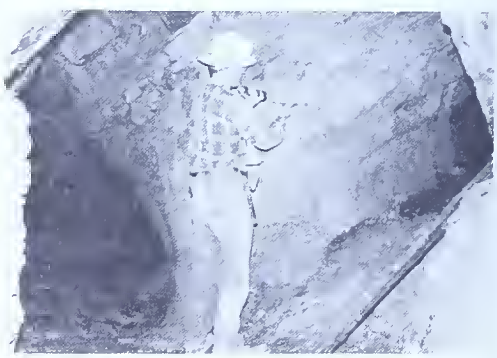


Figure 70. Rich oxidized zinc-lead ore between two geologists in "main floor vein" between the upper and lower levels, Doughty mine.

The "replacement" bed (Figure 71) in the lower level is 14-15 inches (36-38 cm) thick and is exposed for over 6 feet (1.8 m). It disappears behind a dry wall to the southeast, behind which it was probably mined. This bed strikes N65W and dips 35N. It contains abundant hemimorphite and minor galena, smithsonite, anglesite (?), and cerussite.

It is estimated that production from the mine was about 1000 cubic feet (28 m^3) of 20% Zn worth about $15,000 at $0.40 per pound of zinc plus a lesser amount of Pb. On the order of 500 cubic feet (14 m^3) of ore is probably exposed in existing drifts. Johnson (1844, p. 43) reported four or five veins with galena ". . . over a distance of as many hundred yards." It is unlikely, however, that it could be recovered profitably. The occurrence of lead and zinc in replacement beds and small veins at the Doughty Mine, Sunbury, Faylor Quarry, Winfield, and at the Almedia Mine, Bloomsburg, suggests that geochemical exploration of the Tonoloway Formation in this area may be warranted to define targets.

The author gratefully acknowledges that Doughty mine was partly relocated by directions from A. V. Heyl, U. S. Geological Survey, relayed through A. W. Rose, The Pennsylvania State University.

Figure 71. Dark area (to right of hammer) of hemimorphite-limonite ore in "replacement bed" on lower level, Doughty mine.

29. KNISLEY AND SPROUL LIME AND STONE COMPANY QUARRIES, BLAIR COUNTY

(Trace Zinc Occurrences)

1. *Name:* The David Knisley quarry and the Sproul Lime and Stone Company quarry, the latter owned by John E. Claar.

2. *Location:* A. The small, inactive Knisley quarry is located 0.20 mile (0.35 km) northeast of Sproul and 0.70 mile (1.15 km) west of the crest of Dunning Mountain. The water-filled Sproul Lime and Stone Company quarry is located 0.55 mile (0.9 km) southwest of Sproul, on the southeast side of the road toward Queen Station. Both quarries are in Greenfield Township, southwestern Blair County.

B.

	Knisley quarry	Sproul Lime and Stone Company quarry
LATITUDE N:	40° 16′25″	40° 16′05″
LONGITUDE W:	78° 27′21″	78° 28′07″

C. TOPOGRAPHIC MAP: Roaring Spring 7½-minute quadrangle.

3. *Host Rock:* The Knisley quarry is in the Upper Silurian Tonoloway Formation and the Sproul Lime and Stone Company quarry in the Upper Silurian-Lower Devonian Keyser Formation. Mineralization in the Knisley quarry is in laminated shaly limestone. The host rock at the Sproul Lime and Stone Company quarry is well-laminated limestone that has mud cracks on bedding surfaces and is cut by stylolites with clay-carbon insoluble residue.

4. *Estimated Total Amounts of Ore Metals:*

	Knisley quarry	Sproul Lime and Stone Company quarry
<1 g:		
1-1000 g:	Zn	Zn
1-1000 kg:		
>1000 kg:		

5. *Minerals Observed and Relative Amounts:*[1]

A. ECONOMIC

Major:

Minor:

Trace: Sphalerite (orange-brown at Knisley and dark-brown at Sproul Lime and Stone Company), pyrite (octahedral)

1. The pyrite and fluorite at the Knisley and Sproul Lime and Stone Company quarries, as well as the salt casts at the former, are not directly associated with sphalerite.

B. GANGUE

Major:	Calcite (colorless and white, some nailhead crystals; rarely brown)
Minor:	
Trace:	Fluorite (purple)

6. *Paragenesis:* Sphalerite occurs only with secondary calcite.

7. *Geologic Description:* The Knisley quarry is located on the western limb of major anticline at the transition between Valley and Ridge and Appalachian Plateaus provinces where the bedding is N14E, 31W. The attitude of the Tonoloway exposed in the roadcut 0.2 mile (0.35 km) due south of the quarry is N22E, 36W. The crest of Dunning Mountain east of the quarry is part of the same complex overturned anticline with bedding at an average attitude of N30W, 40NE. In a few places, however, bedding on Dunning Mountain is overturned more than 180°! In places, disseminated pyrite is abundant in the Tuscarora Formation ganister quarries just west of the ridge crest. Based on similarities with the Hares Valley occurrences (Smith and others, 1971), it seems likely that minor sphalerite could occur with this disseminated pyrite.

The Sproul Lime and Stone Company quarry is also located in the structural transition zone between the Valley and Ridge and Plateaus provinces. Median bedding in the floor of the old quarry, now water-filled, is N55E, 13NW. Sphalerite was found in both quarries only in float blocks as dark grains in calcite-filled joints perpendicular to bedding.

Neither sphalerite occurrence has any direct economic significance except to demonstrate that trace sphalerite does occur this far west and south in the Tonoloway and Keyser Formations.

These occurrences were kindly brought to our attention by J. Penrose Ambler of Duncansville.

30. LIME BLUFF QUARRY, LYCOMING COUNTY

(Zinc Occurrence With Trace Lead-Copper-Arsenic)

1. *Name:* Lime Bluff quarry owned by Lycoming Silica Sand Co.

2. *Location:* A. The quarry with minor base metals is located 2.3 miles (3.65 km) N39E of the intersection of Pa. Routes 147 and 405 in Muncy. This quarry is 3.75 miles (4.4 km) N57E of the junction of Muncy Creek with the West Branch of the Susquehanna River. The mineralized portion of the quarry lies in Wolf Township, whereas the southwest portion of the quarry is in Muncy Creek Township and the northwest in Muncy Township, all in Lycoming County.

B. LATITUDE N: 41° 13′ 50″ N LONGITUDE W: 76° 45′ 32″ W

C. TOPOGRAPHIC MAP: Muncy 7½-minute quadrangle.

3. *Host Rock:* The upper Tonoloway Formation of Upper Silurian age and possibly the lowermost Keyser Formation probably just below the Silurian-Devonian boundary. The galena and enargite-bearing joint on the south side of the upper level is approximately (estimated, not measured) 40 feet (12 m) below the Keyser, whereas some of the orange sphalerite collected by Thomas O'Neil (personal commun., 1972) and more recently by the author, probably is just above the base of the Keyser Formation.

4. *Estimated Total Amounts of Ore Metals:*

   <1 g:
   1-1000 g: Ba
   1-1000 kg: Pb, Cu, As
   >1000 kg: Zn (lowest end of range)

5. *Minerals Observed and Relative Amounts:*

A. ECONOMIC

Major:	
Minor:	Sphalerite (bright-orange to red to dark-brown), galena (cubic crystals and disseminated blebs along calcite cleavage planes), anglesite (rims on galena and microcrystals)
Trace:	Malachite (coatings and crystals), smithsonite (yellow-gray), enargite* (crystals), pyrite, conichalcite*[1] (yellow-green), cornubite*[2] (bluish-green), azurite (rare prisms to 5 mm), hemimorphite, greenockite

B. GANGUE

Major:	Calcite (dogtooth crystals up to 2 inches (5 cm) and white cleavable masses).
Minor:	Dolomite (salmon to pink crystals in quartz eyes (small nodules) and calcite veins), pyrite (cubes).
Trace:	Fluorite (purple), barite (white and mossy-green prisms)*

6. *Paragenesis:* Solution thinning and accumulation of clay-carbon insoluble residue; pyrite; dark-brown and yellow-gray sphalerite; galena; deformation; orange sphalerite; dolomite trace; clear calcite and galena.

7. *Geologic Description:* The Lime Bluff quarry is located near the northeast-plunging axis of the Nittany Arch where bedding averages N32W, 12NE.

Much of the galena occurs in a 3-inch to 1-foot (8 to 30 cm) wide calcite vein which trends N53E and dips 83SE. Joints in this part of the quarry with only calcite mineralization trend N62 to 64E and dip 81 to 84° to the south. Joints perpendicular to the main vein trend N27W, 75SW and are

1. A hydrous calcium copper arsenate.
2. A hydrous copper arsenate.

often calcite-filled and offset between beds suggesting further deformation along bedding after the joints were filled with calcite. The galena-bearing calcite vein occurs in upper Tonoloway limestone. In addition to galena, this vein contains hypogene enargite and a trace of sphalerite. Unlike many calcite veins in the Tonoloway Formation, this calcite vein does not have a petroleum or fetid odor. Unlike many other calcite veins in the quarry, there is no fluorite. Cavities in this vein contain calcite scalenohedrons up to 2 inches (5 cm) in length. Bedding in the quarry floor and wall near the galena-bearing vein has an orientation of N52W, 23NE and N26W, 26NE. A reverse fault in the west face of the quarry below (on east side of) the entrance road has an attitude of about N65 ± 5W, 55N with the southwest side displaced down. Bedding to the northeast of the fault is approximately N60W, 50N, where bedding to the southwest of the fault is approximately N35W, 16NE. The fault plane projects toward the mineralized joint discussed above. The fault was not observed at the mineralization itself, but the discordant strikes suggest that mineralization was localized by the intersection of a joint and reverse fault.

The sphalerite found in-place occurred in an 8- to 12-inch- (20 to 30 cm) wide calcite vein which has finely crystalline pyrite and a trace of fluorite at its contacts with the wall rock. This vein was underwater when visited by the author, but was first described by Thomas O'Neil (personal commun., 1972) as follows: "The vein trended northeast and dipped approximately 70° to the west. This sphalerite is bright orange and occurred along the walls of the calcite vein. The center of the vein was crumbly calcite." Samples of this vein furnished by O'Neil contain 10-20% sphalerite and a trace (<1 g) of galena. The vein was probably in lowermost Keyser Formation.

A trace of sphalerite (~1 g) was found in a calcite-coated joint on the south-southeast wall of the quarry. This joint trends N72E and dips 88S. It is in lowermost Keyser Formation which has small calcite eyes.

In the summer of 1975, the lower level was pumped out and actively worked. At that time, sphalerite of bright-orange to red color was moderately common in the large loose limestone blocks in the northern portion of the quarry and dark sphalerite with pyrite and galena (with a curved cleavage) in the southern portions. Most of the sphalerite occurred in calcite veins perpendicular to well-laminated platy limestone assumed to be Tonoloway, but some also occurs in massive chert-bearing limestone resembling the Keyser. Some veins have pyrite and trace amounts of sphalerite replacing laminated limestone outside the vein margins. Vuggy quartz eyes (with salmon to pink dolomite crystals) in the laminated limestone have deformed bedding around them suggesting the eyes may have originally been sulfates which developed early. These eyes, together with abundant mud cracks, suggest an arid hypersaline depositional environ-

ment for the Tonoloway here. A few samples of limonite gossan up to 12 inches (30 cm) were found.

Similarities to the Almedia mine occurrence suggest that the possible area for this type of occurrence is larger than previously suspected.

31. LYMEHURST QUARRY, LYCOMING COUNTY

(Trace Zinc-Lead Occurrence)

1. *Name:* The Lymehurst quarry, formerly operated by the West Branch Lime Company (Miller, 1934, p. 532-533), is now owned by George Logue.

2. *Location:* A. The Lymehurst quarry is presently inactive as such and the site of an asphalt plant operated by George Logue. The quarry is located at Lymehurst, 1.0 mile (1.55 km) N30W of the junction of the West Branch Susquehanna River with the main channel of Loyalsock Creek. This area is 1.55 miles (2.5 km) west of the intersection of U. S. Route 220 and Pa. Route 87 in Montoursville. The quarry is at an approximate elevation of 580 feet (177 m) in Loyalsock Township, Lycoming County.

A galena and sphalerite-bearing veinlet is exposed 305 ± 25 feet (93 ± 8 m) east of the west wall of the Lymehurst quarry, in the floor and bottom of the north wall.

B. LATITUDE N: 41° 14′51″ LONGITUDE W: 76° 57′08″

C. TOPOGRAPHIC MAP: Montoursville $7\frac{1}{2}$-minute quadrangle.

3. *Host Rock:* The host rock is limestone in the Silurian Tonoloway Formation. In this area, the Tonoloway Formation is 200-400 feet (60-120 m) thick with the upper part exposed in the Lymehurst quarry (Rodger Faill, personal commun., 1973). The Tonoloway near the sulfides (see number 5 below) consists of dark-gray shaly limestones with common, grossly bed-parallel stylolites on which clay-carbon residues have accumulated, thus indicating that solution thinning has occurred.

Miller (1934, p. 532) described the section in the Lymehurst quarry and presented four chemical analyses. The sulfides galena, sphalerite, and pyrite were observed in beds which are believed to correspond to analyses Nos. 3 and 4 which Miller found to contain sulfur (expressed as SO_3). Miller reports that fossils and sun cracks are common in the more shaly beds. Because the Tonoloway does not generally contain obvious fossils, it is assumed that Miller referred to separate units, the sun cracks being in the Tonoloway Formation and the fossils in the overlying Keyser Formation. The absence of salt casts in the host rock suggests the upper part of the Tonoloway Formation because elsewhere in central Pennsylvania salt casts are common in the lower part of the Tonoloway Formation.

4. *Estimated Total Amounts of Ore Metals:*

A. <g:

1-1000 g:

1-1000 kg: Pb, Zn
>1000 kg:

The above is based on the limonite assay and Miller's (1934, p. 532) report that "Near the east end of the quarry in 1929 a calcite vein from half an inch to 4 inches thick was exposed in which there was considerable galena and a little sphalerite." During the present study, only approximately 10 grams each of sphalerite and galena were observed.

B. ASSAYS: A sample of ten one-inch chips from pyrite-limonite masses (see p. 304) was found to contain 1.70% Zn, 20 ppm Co, 15 ppm Ni, 205 ppm Cu, 720 ppm As, 3.0 ppm Ag, and 370 ppm Pb. The contents of Zn, As, Ag, and Pb are definitely anomalous.

5. *Minerals Observed and Relative Amounts:*

A. ECONOMIC

Major:	Sphalerite (black to lemon-yellow), galena
Minor:	
Trace:	Anglesite

B. GANGUE

Major:	Calcite (coarse white cleavable)
Minor:	Fluorite (light purple)
Trace:	Pyrite,[1] barite*

6. *Paragenesis* (from oldest to youngest): Deposition of Tonoloway, here in a reducing environment; solution along bedding planes and development of cavities up to 4 inches (10 cm) long with accumulation of clay-carbon insoluble residues; folding with slickensiding along bedding; galena, sphalerite (dark first, then lemon-yellow) and pale-purple fluorite; calcite; lemon-yellow sphalerite crystals in calcite vugs. The relative order of deposition of galena, sphalerite, and fluorite is unknown. Some sphalerite occurs outside the calcite veins, apparently replacing small coarsely crystalline calcite eyes in limestone near the veins.

The pyrite masses (see above) that replaced limestone farther west in the Lymehurst quarry presumably formed about the same time as the galena and sphalerite. The pyrite masses are now partly altered to limonite.

7. *Geologic Description:* The trace lead-zinc mineralization at Lymehurst occurs in the Tonoloway Formation on the north limb of the Nittany anticline about 10 miles (16 km) west of its topographic terminus. The Lime Bluff lead-zinc occurrence (near Muncy) is located in the same stratigraphic horizon near the northeast plunge of the Nittany anticline.

For the entire quarry, R. T. Faill (personal commun., 1973) obtained an east-west bedding attitude and a dip of 19N. The quarry is located in the

1. Pyrite also occurs as massive replacement bodies up to a foot (30 cm) across. These retain bedding textures and include small bed-parallel vugs with cubic pyrite crystals and thin colorless barite* blades.

north limb of a fourth-order fold with a rather planar north limb and narrow fold hinge.

To the west of the Lymehurst quarry, there is a small abandoned quarry in the Tonoloway Formation just east of the Loyalsock Township building. Here it can be seen that the fourth-order anticline of the Lymehurst quarry is probably of kink-band origin (Faill, 1973), i.e., resulting from two kink planes in the north limb of the Nittany anticline.

Bedding attitude near the sphalerite and galena-bearing calcite vein is N80W, 23N. This vein is approximately ½-inch (1-2 cm) thick and trends N20E, 90°. Near the sphalerite and galena-bearing vein, slickensides on abundant bed-parallel clay-carbon stylolites are common. Traces of sphalerite and galena also occur in these slickensided stylolites. This is probably bed No. 3 of Miller (1934, p. 532). The richer vein described by Miller from the east end of the quarry was not observed. There are no obvious faults and there are fewer calcite veins in the Tonoloway at Lymehurst than at Lime Bluff (near Muncy) or at Lime Ridge (near Almedia).

Zinc-bearing pyrite masses up to about 8 inches (20 cm), weathering to limonite, were found 250 $\pm$ 25 feet (75 $\pm$ 7.5 m) east of the west end of the quarry, approximately 12 feet (4 m) above the quarry floor. The nodules show relict bedding laminae and are probably a replacement of laminated Tonoloway limestone. The strike of bedding here varies from N85W to N85E, whereas the dip is rather constant at 18 $\pm$ 2N.

Unlike most other occurrences of lead and zinc in the Tonoloway Formation of Pennsylvania, a trace of purple fluorite is associated with sulfides. The calcite veins here do *not* have a fetid, sulfurous, or petroleum odor as was reported by Miller (1934, p. 531) for the same formation at the Pine Creek Lime and Stone Company quarry about one mile (0.6 km) southwest of Jersey Shore: "In one of the calcite veins a small amount of petroleum, perhaps half a teaspoonful, was found. It was clear and burned readily. The workmen report that occurrences of this kind are not rare. The cavity in which the oil was found was lined with calcite crystals." Likewise, Tonoloway Formation samples from Altoona and Mapleton collected during the present study were found to contain ". . . fairly high levels of the lighter hydrocarbons in the range of C_1 to C_7" (James Griffith, Mobil Oil Corp., personal commun., 1973).

The lead and zinc occurrence at Lymehurst is, in itself, of no economic significance. However, it further documents the widespread but generally sparse occurrence of zinc and lead minerals in the Silurian Tonoloway Formation of Pennsylvania. The presence of trace amounts of replacement and solution thinning, both considered favorable for larger concentrations of these elements, suggest the possibility of larger occurrences in the area.

32. THOMPSON LEAD MINE, HUNTINGDON COUNTY

(Abandoned Lead-Zinc Prospect)

1. *Name:* Thompson Lead Mine, owned by Richard Thompson.

2. *Location:* A. A trench and a few pits 1.15 miles (1.9 km) due north [not northeast, as reported by White (1885), Miller (1924), and Wedow and others (1968)] of McConnellstown, and 0.3 mile (0.5 km) east of Crooked Creek. The workings (see Figure 72) are located on the southeast side of a gulley known locally as "Lead Mine Hollow," Walker Township, Huntingdon County.

B. LATITUDE N: 40° 28′ 10″ LONGITUDE W: 78° 04′ 58″

C. TOPOGRAPHIC MAP: Huntingdon $7\frac{1}{2}$-minute quadrangle.

3. *Host Rock:* Silurian Tonoloway limestone. Approximate measurements from the Keyser Formation outcrops to the east suggest that the workings are located in the lower to middle Tonoloway Formation. The observed sulfides appear to be confined to a joint where it passes through a particular 4-foot (1.2 m) thick massive bed of gray to very dark (hydrocarbon residues?) fine-grained limestone that is unfossiliferous. The limestone in the area of the pits contains mud polygons, but no halite casts that would directly prove hypersaline conditions.

4. *Estimated Total Amounts of Ore Metals:*

<1 g:
1-1000 g:
1-1000 kg: Pb and Zn
>1000 kg:

5. *Minerals Observed and Relative Amounts:*

A. ECONOMIC

Major:	
Minor:	Sphalerite (lemon-yellow to orange-brown, the latter fluorescent), galena (both cubic crystals with a curved cleavage and fine-grained aggregates).
Trace:	Hydrozincite

B. GANGUE

Major:	Calcite (scalenohedrons, some strongly phosphorescent).
Minor:	Fluorite (sparse octahedrons; generally massive, blue-purple, light-green, and colorless).
Trace:	Dolomite

6. *Paragenesis:* Sphalerite and galena; calcite and fluorite; dolomite.

7. *Geologic Description:* The workings are on the north-northwest limb of the gentle Broad Top syncline where the bedding is N14E, 14SE.

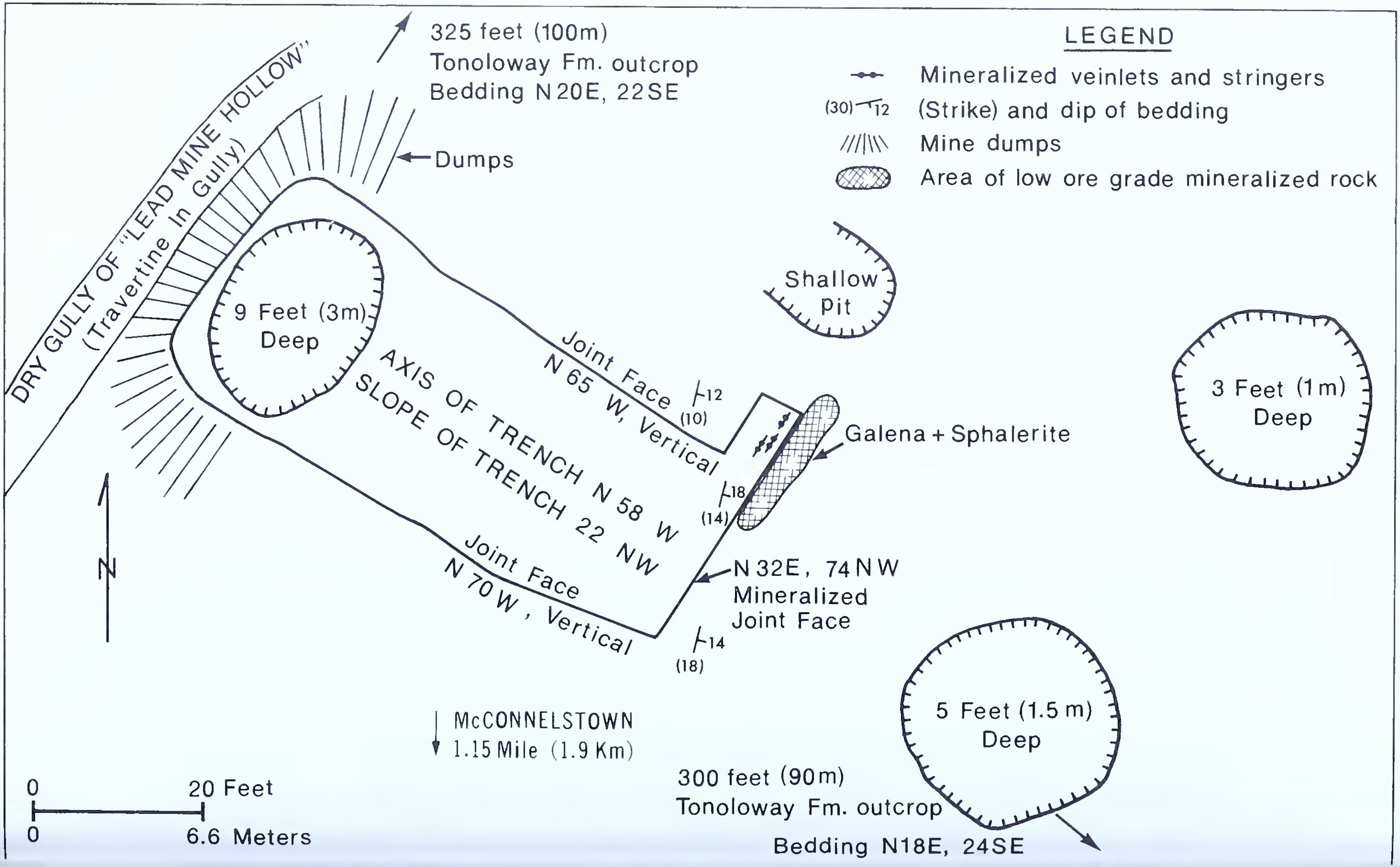


Figure 72. Workings and geology of the surface portions, Thompson Lead Mine, McConnellstown, Huntingdon C...

The only in-place mineralization observed occurs along and near a joint face that trends N32E, 74NW (see Figure 72). This joint is approximately parallel to the long axis of the gulley (Lead Mine Hollow). This dry, narrow gulley is on the order of 12 feet (3.6 m) deep and contains a few large blocks of cave travertine. The presence of this travertine suggests that the gulley may have developed by collapse of a cave which developed along a joint or minor fault parallel to the mineralized joint. In a tiny quarry approximately 375 feet (115 m) north-northeast of the mineralized workings, bedding is crumpled and possibly faulted. This tiny quarry lies on the projection of the long axis of the deep gulley, but no metallic minerals were observed here.

The mineralized bed has a second fracture set which is vertical and has a spacing of 6-8 inches (15-20 cm). These fractures occur elsewhere in the trench as a pronounced joint set roughly parallel to the long axis of the trench (see Figure 72). These vertical joints trend N70W and are sometimes coated with calcite crystals, but neither sphalerite nor galena were observed on this set (c. f. Knisley quarry, Blair County).

Smith and others (1971) speculated that a large-scale control on base metal sulfide localization such as that at the Thompson mine might be a northwest-trending, mineralized lineament extending from the Piedmont to the Allegheny Plateaus. Although the Thompson mine occurrence is minor, it shows that zinc-lead mineralization is possible in the limestones of Huntingdon County.

33. WINFIELD QUARRY, UNION COUNTY

(Active Limestone Quarry Which At Times Encounters Small Ore-Grade Zinc-Lead Zones)

1. *Name:* Winfield quarry owned by Faylor Lime and Stone Co.

2. *Location:* A. The Winfield quarry is located 0.7 mile (1.1 km) southwest of Winfield, Union Township, Union County. The quarry is 4.2 miles (6.7 km) southwest of the junction of the east and west branches of the Susquehanna River and about 1500 feet (400 m) south of Pennsylvania Route 304.

B. LATITUDE N: 40° 54′ 16″ LONGITUDE W: 76° 51′ 57″

C. TOPOGRAPHIC MAP: Northumberland $7\frac{1}{2}$-minute quadrangle.

3. *Host Rock:* From north to south, the quarry exposes the Upper Silurian Tonoloway Formation, Upper Silurian and Lower Devonian Keyser Formation and the lower Devonian Old Port Formation. Sphalerite, galena, celestine and calcite are located in the upper part of the Tonoloway, whereas the more-recently-found iron phosphates are probably in the Shriver Member chert of the Old Port. The laminations, algal heads and mud cracks suggest that the Tonoloway is an algal laminite deposited in an arid environment.

4. *Estimated Total Amounts of Ore Metals:*
   <1 g:
   1-1000 g: Cu, Cd
   1-1000 kg:
   >1000 kg: Zn, Pb (Probably more than 10 tons of Zn and about $\frac{1}{5}$ of this amount of Pb.)

5. *Minerals Observed and Relative Amounts:*[1]

A. ECONOMIC

Major:	Sphalerite (dark-brown with pyrite replacing laminated limestone and bright-orange in calcite veinlets)
Minor:	Galena (cleavages in veinlets, rare cuboctahedrons)
Trace:	Smithsonite, anglesite and greenockite

B. GANGUE:[2]

Major:	Calcite (coarse, white cleavable masses, some fetid), pyrite (disseminated to massive replacing limestone and cubes and/or pyritohedrons in white calcite).
Minor:	Quartz (smoky crystals), dolomite (white cleavages), celestine (blue prisms but not with Zn-Pb).
Trace:	Barite* (white cleavages in calcite), strontianite,[3] fluorite (purple-pink, but not with Zn-Pb).

6. *Paragenesis:* Disseminated pyrite in laminated limestone; solution and stylolite development; dark sphalerite, pyrite and galena veinlets cutting pyrite; orange-brown to lemon-yellow sphalerite and galena in calcite; deformation; dolomite, quartz, pyrite, barite and strontianite; supergene anglesite, smithsonite, and greenockite. Often, the galena appears later than associated sphalerite. Fluorite was not observed to occur directly with ore minerals.

7. *Geologic Description:* The Winfield quarry is located on the south limb of the Berwick anticline, in a position similar to the Almedia zinc-lead

1. Tom O'Neil (personal commun., 1973) reports a 3-foot (1 m) "limonite" bed in the south wall of the quarry. Vivianite (rare), cacoxenite and strengite(?) occur in limonitic, crinoidal, cherty limestones. These minerals are not directly associated with zinc-lead mineralization.
2. Lapham and Geyer (1969) also reported rhodocrosite, but this is doubtful.
3. Measured densities of 3.61 ± 0.02 suggest a CaO content on the order of 10%. The so-called "strontian calcite" crystals of orange color which fluoresce and phosphoresce, have a density of $2.74 \pm .01$. This density permits little SrO. J. A. Speer (personal commun., 1975) reports that Winfield strontianite contains 7.3% CaO, 0.3% BaO, and 0.05% PbO and that the so-called "strontian calcite" contains only 0.1% SrO.

mine near Bloomsburg. Unlike the other anticlines in the Susquehanna forks region, the Berwick anticline does not plunge rapidly to the east. No detailed geologic maps are available for Union County.

The rich sphalerite and galena ore-grade rock observed in 1972 was located in an intermediate level haulage road on the north side of the quarry, and about two-thirds of the way toward the west end of the quarry. When visited shortly thereafter with A. W. Rose of The Pennsylvania State University, it was agreed that the ore consisted of replacement of pyrite-bearing, laminated limestone (Figure 73). Calcite and sphalerite gash veins trended through the replacement ore at about N20E, approximately parallel to barren calcite veins in the north wall of the quarry. Bedding in this portion of the quarry was fairly constant and yielded a median attitude of N77E, 44S. A few months before, more than 10 metric tons of rock containing over 10% combined Zn plus Pb was lying about in an area 42 ± 10 feet (13 ± 3 m) beneath the Keyser, placing it somewhat below the zone of choice celestine crystals for which the Winfield quarry is noted. When visited in 1967, only a few ounces of ore minerals in calcite veins were observed. However, large ore-grade samples have been obtained by mineral collectors both prior to and following 1972 (Donald Hoff and Tom O'Neil, personal commun., 1974). When visited again in the fall of 1975, only trace mineralization was exposed. If the occurrence had been found in the 19th century, it is probable that attempts would have been made to mine it.

Rogers (1858, p. 460) noted that "Galena has been found in thin lodes traversing the calcareous spar-veins in the limestone; but no workable vein has ever been discovered." This refers to Buffalo Valley, the first valley north of the Berwick anticline, which is underlain by the Keyser, Tonoloway, and Wills Creek Formations. Such minor occurrences together with the grades observed at the Winfield, Doughty mine, and Almedia mine occurrences, suggest that the upper Tonoloway warrants at least stream sediment geochemical prospecting within a 50-mile (80 km) radius of Danville, Montour County.

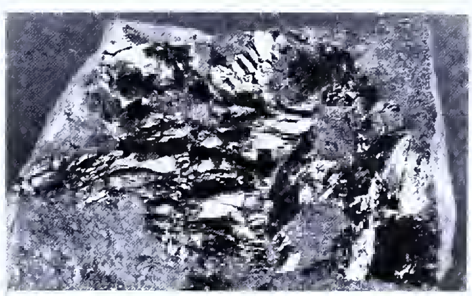


Figure 73. Coarse galena cleavages in pyrite which has replaced laminated limestone, Faylor quarry at Winfield, Union County.

SILURIAN (TUSCARORA FORMATION) OCCURRENCES

34. HARES VALLEY AREA, HUNTINGDON COUNTY

(Abandoned, Very Small Lead-Zinc Prospects
And Untested Minor Occurrences)

1. *Name:* The Hares Valley area including the Shaughnessy Run quarry, probably on the new extension of State Game Lands No. 5; the U. S. Route 22 roadcut right-of-way and adjacent property owned by Harry H. Boettcher; the ConRail railroad cut near Mapleton; the 1300-foot quarry, reportedly owned by Harbison Walker, adjacent to State Game Lands No. 171; the Scrub Run quarry, probably owned by the Mapleton Water authority; the Richard Hammon mine, adit, and prospect on Silver Mine Knob owned by the Silver Mine Knob Hunt Club; and "P. Hammon - G. Schaffer Gold mine," in the Singers Gap Reservoir watershed; and a lesser occurrence of unknown ownership.

2. *Location:* Approximately from north to south.

A. Occurrence No. 1, a ganister quarry on the southeast side of Shaughnessy Run, is located at an elevation of about 1300 feet (400 m), 4100 feet (1250 m) S46E of Shaughnessy Run at U. S. Route 22, and 5500 feet (1690 m) S86W of the 2321-foot crest of Jacks Mountain, Brady Township. Sulfides occur in the northern parts of the quarry and gossan in the southeast.

Occurrence No. 2, in the portion of another ganister quarry between 1440 and 1500 feet (440 and 460 m) elevation, location 5950 feet (1780 m) S17E of Shaughnessy Run at U. S. Route 22, and 7600 feet (2300 m) N46E of the triangle in Mapleton, Brady Township. This is location 4134 of Smith and others (1971).

Occurrence No. 3, an old exploration trench (location 4133 of Smith and others, 1971) (Figure 74), is located on a ridge crest at an elevation of about 1250 feet (380 m), 3900 feet (1190 m) N87E of the junction of Smith Run and Juniata River, and 5275 feet (1600 m) N60E of the triangle in Mapleton, Brady Township.

Figure 74. Occurrence No. 4133 in a trench cutting the "quartzite" ridge of the Tuscarora Formation, Hares Valley area, Huntingdon County. The diameter of the tree growing in almost nonexistent soil suggests that the trench is very old.

Occurrence No. 4, an old exploration pit (location 4132 of Smith and others, 1971), is located on the southeast side of a ridge crest at an elevation of about 1170 feet (325 m), 3700 feet (1320 m) S86E of the junction of Smith Run and Juniata River, and 4450 feet (1375 m) N63E of the triangle in Mapleton, Brady Township.

Occurrence No. 5, the overgrown, northern edge of a ganister quarry, is located on the southeast flank of a ridge at an elevation of about 1050 to 1100 feet (338 m), 3950 feet (1200 m) S83E of the Junction of Smith Run and Juniata River, and 4550 feet (1390 m) N67E of the triangle in Mapleton, Brady Township.

Occurrence No. 6, an outcrop and shallow drill core hole on the northeast side of U. S. 22 (Figure 75), is located at an elevation of about 660 feet (200 m), 1500 feet (460 m) west-northwest of the intersection of the road from Mapleton onto U. S. 22, 1800 feet (550 m) southeast of the office for Motel 22, 1650 feet (500 m) S64E of the junction of Smith Run and Juniata River, and 1775 feet (545 m) N75E of the triangle in Mapleton, Brady Township. The drill hole was collared 13 feet 1 inch (3.98 m) northeast of the white line on the east berm of U. S. Route 22 and 20 feet (6.10 m) southeast of the center of an iron-barred culvert.

Occurrence No. 7, a 300-foot- (90 m) long series of mineralized outcrops along the ConRail (Penn Central) tracks, is located at an elevation of about 600 feet (185 m), 4150 (1275 m) feet S44E of the junction of Smith Run and Juniata River, 3600 feet (1090 m) S87E of the triangle in Mapleton, Union Township.

Occurrence No. 8, in the southeast face of a ganister quarry at an elevation of about 1300 feet (400 m), is located 3650 feet (1110 m) S27E of the triangle in Mapleton, and 2700 feet (825 m) N30E of Scrub Run, Union Township.

Occurrence No. 9, in the west end of a ganister quarry, is located at an elevation of about 910 feet (278 m), 200 feet (60 m) northeast of Scrub Run

Figure 75. Core drilling at the Motel 22 galena occurrence to determine geologic structure, Hares Valley area, Huntingdon County.

reservoir, and 5400 feet (1660 m) S4E of the triangle in Mapleton, Union Township.

Occurrence No. 10, the Richard Hammon mine (now obstructed because the mouth of the adit has now caved, but with a moderate-size dump. Figure 76), is located on the northeast nose of Silver Mine Knob below road level at an elevation of about 1340 feet (410 m), about 400 feet (120 m) south-southeast of the creek junction in Querry Gap, and 2050 feet (630 m) N17E of the summit of Silver Mine Knob, Union Township. There is a large, double-trunked oak tree along the road (a trail on the topographic map) at an elevation of 1440 feet (440 m) directly uphill and to the west of the mine.

Occurrence No. 11, a caved-in adit about 10-15 feet above road level (Figure 77), is located at an elevation of about 1450 feet (440 m) along a road at an elevation of 1440 feet (440 m), 1850 feet (560 m) N19E of the summit of Silver Mine Knob, and 550 feet (170 m) S24W of the creek junction in Querry Gap, Union Township.

Occurrence No. 12, a small prospect east side of the crest of Silver Mine Knob, is located at an elevation of 1700 feet (515 m), 1100 feet (335 m) due north of the summit of Silver Mine Knob, and 1350 feet (415 m) S33W of the creek intersection in Querry Gap, Union Township (Figure 78).

Occurrence No. 13, merely the area where a mass of pyrite was found, is located along a pipeline about 1300 feet (400 m) southwest of the summit of Silver Mine Knob.

Figure 76. Extensive dumps from mine at occurrence 10, Silver Mine Knob, Hares Valley area, Huntingdon County. The dump extends 40 feet (12 m) along its top in a direction perpendicular to an otherwise 30° sloping hill. (Arrow indicates long axis of dump.)

Figure 77. Caved-in entrance to occurrence 11, Silver Mine Knob, Hares Valley area, Huntingdon County.

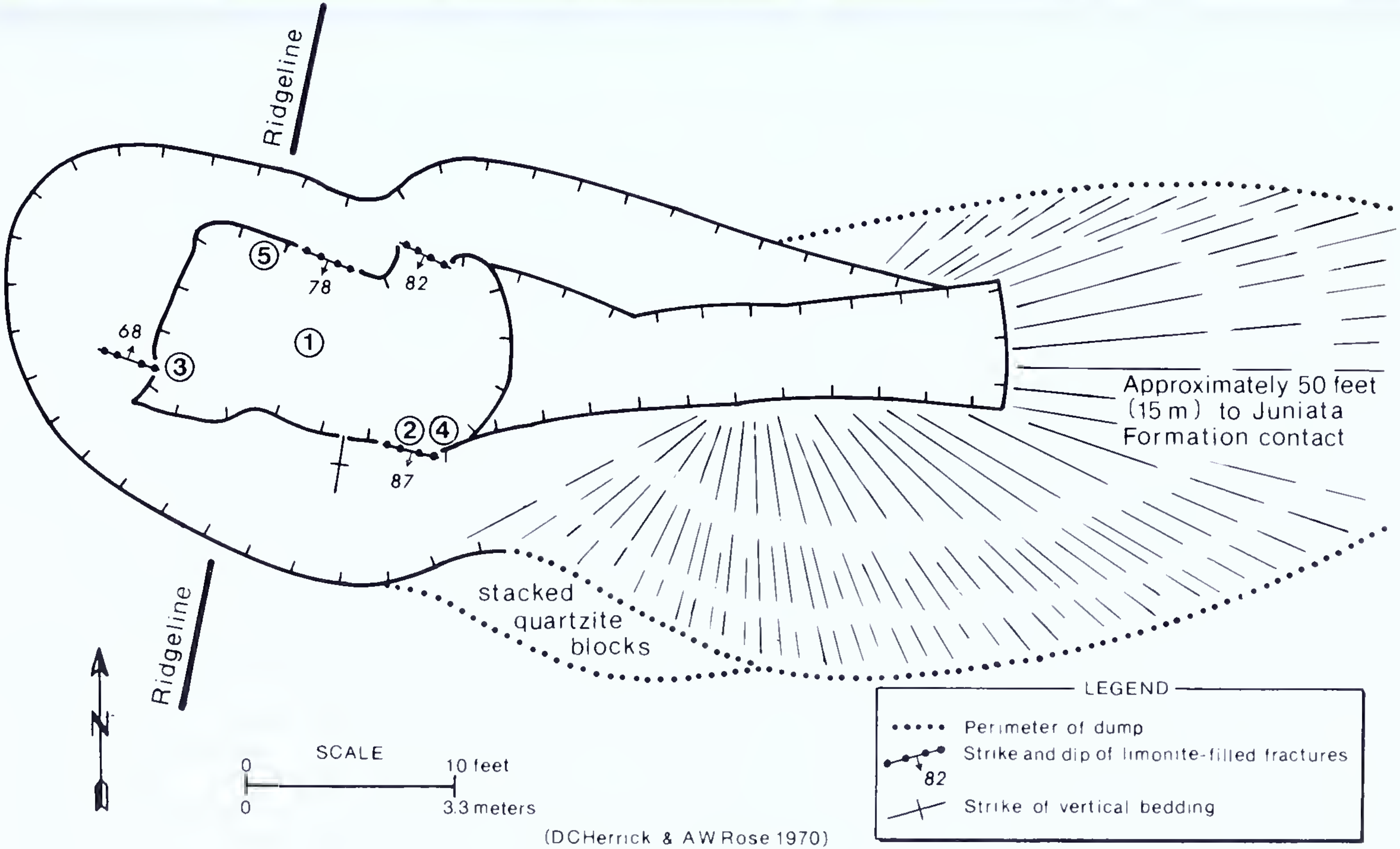


Figure 78. Map of pit on Silver Mine Knob (occurrence No. 12), Hares Valley area. (1) Present maximum depth—15 ft (4.6 m). (2) Fractured zone ¼ to 2 in. (0.5-5 cm) wide. (3) Fractured zone up to 5 in. (13 cm) wide. (4) Ten in. (25 cm) diameter yellow birch growing in pit. (5) NW-trending fractures have ⅛ to ½ in. (0.2-1 cm) red-orange limonite coatings.

Occurrence No. 14, the small Peter Hammon - George Schaeffer "Gold Mine" pit, is located at an elevation of about 1310 feet (400 m), just on the north side of an unnamed gully which eventually empties into the southern end of Singers Gap Reservoir, 4600 feet (1400 m) S44E of the summit of Silver Mine Knob, Shirley Township. The pit is S43W of a large pile of sawdust from an old mill.

B.

		LATITUDE N	LONGITUDE W
1	Shaughnessy Run quarry	40° 24′56″	77° 55′06″
2	4134 quarry	40° 24′28″	77° 55′20″
3	4133 trench	40° 23′58″	77° 55′37″
4	4132 pit	40° 23′56″	77° 55′40″
5	Wooded ganister quarry	40° 23′53″	77° 55′36″
6	Motel 22 drill hole	40° 23′44″	77° 55′50″
7	ConRail outcrops	40° 23′33″	77° 55′45″
8	1300-foot quarry	40° 23′04″	77° 56′10″
9	Scrub Run quarry	40° 22′43″	77° 56′27″
10	R. Hammon mine	40° 20′06″	77° 57′29″
11	Silver Mine Knob adit	40° 20′05″	77° 57′32″
12	Silver Mine Knob pit	40° 19′58″	77° 57′40″
13	Bloomsburg pyrite	~40° 19′44″	~77° 57′56″
14	P. Hammon - G. Schaeffer "Gold Mine"	40° 19′16″	77° 56′59″

C. TOPOGRAPHIC MAP: Occurrence numbers 1 through 9 are on the Mount Union 7½-minute quadrangle and numbers 10 through 14 on the Butler Knob 7½-minute quadrangle.

3. *Host Rock:* All of the observed mineralization is in Lower to Middle Silurian clastic rocks, mainly of the Lower Silurian Tuscarora Formation.

Occurrence No.	Host Rock
1	Tuscarora quartzite, probably upper to middle.
2	Tuscarora quartzite, possibly middle
3	Tuscarora quartzite, probably lower.
4	Tuscarora quartzite, probably lower.
5	Tuscarora quartzite with a greenish-yellow weathered surface.
6	Tuscarora quartzite, probably upper, in fault contact with Rose Hill shale. Castanea member missing by faulting.
7	Lowest third of Tuscarora, here impure, finer-grained, and pyritic. Much interbedded, fissile gray shale.
8	Upper Tuscarora in bastard ganister with pyritic beds.
9	Upper half of Tuscarora, here impure with abundant shaly beds and "arthrophycus" fossils.

10	Lowermost Tuscarora quartzite with some "pink Tuscarora" or upper Juniata Formation.
11	Lowermost Tuscarora quartzite.
12	Tuscarora quartzite.
13	Probably Bloomsburg Formation. Samples were found as float from a trench, but are delicate and were probably almost in place.
14	Gray coarse crystalline dolomite with crinoid fossils and carbonaceous residue. Probably part of the McKenzie-Mifflintown Formation.

4. *Estimated Total Amounts of Ore Metals:*[1]

A.

Occurrence No.	<1 g	1-1000 g	1-1000 kg	>1000 kg
1	Ag	Pb, Zn, Cu		
2		As		
3		As, Cu, Pb, Hg	Zn(?)	
4		As, Cu		
5		Pb, Zn		
6			Cu, Ag, Au	Zn, Pb
7		Ag		Zn, Pb
8		Pb, Cu, As	Zn	
9			Zn, Pb	
10	Cu(?)	Zn		
11	Hg	As		
12	Ag	As, Pb		Zn
13	Ag	Pb(low end of range)		
14		Cu		

B. ASSAY:

a. Mineralized quartzite samples

Occurrence No.	Internal feet	meters	Zn%	Pb%	Ag	Au	S%	Cu ppm	Co ppm	Ni ppm	As ppm
6	0-2	0-.6	2.00	.85	tr.	tr.	6.9	765	10	5	240
(drill core)	2-8	.6-2.4	3.15	10.1	.78oz	tr.	4.9	350	<5	5	60
	8-11.1	2.4-3.4	3.15	1.29	tr.	.01oz	3.8	465	<5	<5	45
	11.1-21.7	3.4-6.6	.39	.26	tr.	tr.	.4	50	5	<5	<5
6	0-12	0-3.7	.51	.23	2ppm						
(rock chip)	12-21.5	3.7-6.6	.48	.07	<1ppm						

1. The estimates reported here may be very low for occurrence number 1, 2, 3-5, 9, and 12, based on the magnitude of anomalies and transport rate of stream sediment. For example, stream sediment anomaly 4048 (Smith and others, 1971) with 0.35% Zn may indicate substantial zinc toward Querry Run.

Occurrence No.	Internal feet	meters	Zn%	Pb%	Ag	Au	S%	Cu ppm	Co ppm	Ni ppm
7	56-110	17-34	.18	.10	<1ppm	N.A.	1.1		15	20
(rock chip)[2]	155-200	48-61	.06	.23	1	"	1.0		15	20
	200-272	61-83	.29	.08	1	"	1.0		15	20
	272-305	83-94	.04	.05	1	"	1.3		15	25
	305-390	94-119	<.01	<.01	<1	"	.8		10	15
	390-429	119-131	<.01	<.01	<1	"	.5		5	10

b. Limonite gossan and pyrite samples (analyses in ppm)[2]

Occurrence No.	Co	Ni	Cu	Zn	As	Ag	Pb
1	<5	10	200	30	330	0.6	130
2	14	18	136	27	545	<1	90
3	19	15	320	69	780	3	210
4	14	13	202	24	700	<1	70
12	<5	<10	108	22	1000	<1	900
13	40	30	25	190	N.A.	3	60?
"Breccia," south of Silver Mine Knob	5	<5	75	60	1300	0.1	130

c. Selected stream-sediment-sample analyses (in ppm):[3]

Samples	Co	Ni	Cu	Zn	Pb	Fe%	Mn%	Hg ppb	Location
Shaughnessy Run	65	125	20	810	180	—	—	—	Near occur. 1
4115	6	60	18	1090	95	2.2	.14	115	Downslope from occur. 1
4116	147	44	42	1060	95	3.8	.07	250	SE occur. 3, 4, and 5
4117	14	84	48	200	55	3.5	.38	190	E of 4116
4144	52	170	154	359	65	2.6	.44	300	Lower Deep Hollow
4146	60	250	36	235	60	3.3	.78	205	Upper Deep Hollow
4145	30	85	31	163	35	1.7	.35	105	Upper Deep Hollow

2. From Smith and others (1971).

3. From Smith and others (1971). See this reference for analytical procedures and additional data.

Samples	Co	Ni	Cu	Zn	Pb	Fe%	Mn%	Hg ppb	Location
4088	21	56	22	735	95	3.2	.20	115	Lower Scrub Run
4091	25	50	26	775	135	3.2	.25	135	Middle Scrub Run, SW occur. 9
4092	13	46	17	225	25	3.4	.21	145	Middle Scrub Run, S occur. 9
4089	84	92	16	170	55	3.6	.39	150	Upper Scrub Run, SE occur. 9
4090	22	60	27	300	30	4.4	.22	145	Upper Scrub Run, SE occur. 9
4102	8	52	41	260	30	3.5	.18	105	Upper part of S branch of Scrub Run
4101	7	42	23	95	30	3.4	.17	105	Upper part of S branch of Scrub Run
4103	12	62	27	440	30	3.7	.31	135	Upper part of S branch of Scrub Run
4104	7	54	28	200	40	4.0	.18	125	Upper part of S branch of Scrub Run
4105	4	86	15	325	25	2.5	.29	95	Upper part of S branch of Scrub Run
4106	4	37	31	150	25	3.4	.16	110	Upper part of S branch of Scrub Run
4070	<5	25	18	508	60	2.0	.07	210	Lower Beech Run
4087	5	63	14	1060	55	2.2	.17	110	N branch Beech Run
4086	10	38	14	670	65	2.8	.14	110	E branch Beech Run
4081	22	34	36	305	20	2.8	.01	135	Upper E branch Beech Run

Samples	Co	Ni	Cu	Zn	Pb	Fe%	Mn%	Hg ppb	Location
4069	23	25	22	158	40	2.8	.14	95	Small trib. to Hares Valley Creek, 0.6 km SW Beech Run Ch.
4046	5	15	21	415	60	3.3	.13	60	Querry Run along Pa. 655
4072	18	35	15	439	80	2.7	.16	55	Querry Run at foot of 1055 knob
4080	20	25	13	375	70	2.3	.14	55	Querry Run, SSE of 1055 knob
4078	33	40	20	250	35	2.4	.24	70	Querry Run, SE of 1055 knob
4048	385	412	61	~3500	65	12.6	1.21	145	Small trib. to Querry Run at 1090 elevation
4077	<5	25	11	57	10	1.9	.09	50	Querry Run at mouth of gap
4075	<5	10	11	38	5	1.3	.04	60	N branch Querry Run from Chestnut Flat
4076	6	30	8	60	25	2.3	.13	190	S branch Querry Run
4074	14	105	22	456	65	4.0	.16	60	Pipeline downslope occur. 13
4073	23	75	21	179	35	3.7	.22	85	Along road around Silver Mine Knob at 1150 elevation

Samples	Co	Ni	Cu	Zn	Pb	Fe%	Mn%	Hg ppb	Location
P.H.-G.S. "Gold Mine"	15	25	5	60	—	—	—	—	

d. Selected Soil Sample: Zinc and lead determinations analyses for upper B-zone soils along a portion of a traverse done by Smith and others (1971), are presented in Plate 5a. The values reported are the result of extraction with hot nitric acid which was shown to have extracted about 65% of the zinc and 70% of the lead. The first number shown on the map is zinc and the second, lead, both in ppm.

e. Galena Concentrates:

Location No. 6 outcrop	% Pb	oz/ton silver	oz/ton gold	oz/silver ton galena
Sample A[4]	49.	2.85	.01	5.0
Sample B	79.5	4.96	.005	5.3

5. *Minerals Observed and Relative Amounts:*

A. ECONOMIC

Occurrence No.	Major	Minor	Trace
1			Sphalerite (brown), galena
2			
3			
4			
5			Galena (brownish-tarnish and curved cleavage), sphalerite (bright-orange and yellow)
6	Galena (some curved cleavage), sphalerite (red, orange, yellow, brown and black)	Anglesite* (white coating on galena)	Chalcopyrite, plumbojarosite* (yellow-brown coating on galena), pyromorphite*[5] (white fibrous and gray prismatic)

4. M. L. Keith, personal commun., 12/31/71.
5. X-ray diffraction suggests an OH-rich pyromorphite, i.e., lead hydroxyapatite.

Occurrence No.	Major	Minor	Trace
7	Sphalerite (orange, some fluorescent), galena		Anglesite (coating on galena nuggets)
8		Sphalerite (dark-ruby red to red-orange)	Galena, chalcopyrite, anglesite, tennantite*[6]
9		Sphalerite (brownish-red), galena (rapidly develops a brown tarnish)	Anglesite
10			Sphalerite (orange-brown)
11			
12			
13			
14			Chalcopyrite

B. GANGUE

Occurrence No.	Major	Minor	Trace
1	Pyrite (disseminated)	Quartz (drusy, colorless crystals)	Muscovite 1M* (orangish-flakes on fractures)
2	Limonite		
3	Limonite		
4	Limonite		
5		Pyrite	
6	Pyrite* (disseminated and modified cubes)	Quartz (drusy, colorless crystals)	Hydroxyl-apatite*[7]
7	Pyrite (disseminated and in quartz veins)	Jarosite (greenish-golden coating on fractures in quartzite)	Apatite*

6. SEM qualitative analyses confirm the presence of arsenic and lack of antimony (Donald Schmerling, personal commun., 1976).

7. X-ray diffraction suggests hydroxyl-apatite (ϵ=1.629, ω=1.633 and c/a=0.7355), but this cannot be distinguished with certainty from fluorapatite. This mineral is a normal Ca-bearing apatite in contrast with the previously mentioned pyromorphite.

Occurrence No.	Major	Minor	Trace
8	Quartz (drusy crystals)	Pyrite (disseminated pyritohedral, crystals along joints, and ovid nodules of granular pyrite up to 2 inches (5 cm).	
9		Quartz (drusy, colorless crystals)	
10	Pyrite (disseminated)	Quartz (drusy, colorless crystals)	
11		Pyrite (disseminated)	
12	Limonite		
13	Pyrite	Melanterite	
14	Dolomite (coarse-grained salmon-colored)		

6. *Paragenesis:* At most localities the paragenesis could not be determined. At the few where it could, the descriptions are given below:

Occurrence No. 6: Deposition of sandstone, probably containing disseminated, syngenetic(?) pyrite; brecciation; quartz crystals; pyrite and dark sphalerite; light sphalerite; galena; deformation (slickensiding of pyrite and distortion of galena). Light sphalerite and galena may be contemporaneous, and there may be a younger stage of quartz. The hydroxyl-apatite is younger than at least some of the pyrite and quartz.

Occurrence No. 8: Deposition of sandstone; crystalline quartz, disseminated pyritohedral pyrite; sphalerite; chalcopyrite, pyrite; and galena. Because of scarcity, the relative ages of chalcopyrite and the younger pyrite are uncertain with respect to each other and the rest of the sequence. Tennantite is probably young with respect to the hypogene minerals.

Occurrence No. 9: Deposition of sandstone with disseminated syngenetic(?) pyrite; drusy quartz crystals; sphalerite; and galena. There is some overlap as shown by the presence of trace galena and rarely sphalerite in the tips of the quartz crystals.

7. *Geologic Description:* The observed mineralization in the Hares Valley area is located in the steeply-dipping to overturned northwest limb of the Jacks Mountain anticline. This anticline, one of the major anticlines in south central Pennsylvania tends to have a subvertical northwest limb, whereas the southeast limb typically dips at about 30°. Neither the Mount Union nor Butler Knob 7½-minute quadrangles had ever been mapped accurately, but H. W. Schasse has recently mapped the Reedsville through Oriskany ("Old Port") portions of the anticline as part of a master's thesis at The Pennsylvania State University. His maps, made available to the Pennsylvania Geological Survey to modify the state geological map, verify and extend a major fault first reported by Rose in Old Woman's Gap (Smith and others, 1971). This reverse fault, which extends greater than 12 miles (19 km) and has greater than 1600 feet (500 m) movement, has displaced the southeast side of the anticline downward, and appears to be dipping steeply to the northwest (A. W. Rose, personal commun., 1976). Another important, but smaller, fault follows the south shore of the Juniata River east of Mapleton. As mapped by Schasse (personal commun., 1976), this cross fault appears to be sub-vertical, with right-lateral displacement in a horizontal direction. Schasse's thesis (in preparation) should be consulted for precise structural information.

Occurrence numbers 1 through 9 occur along a broad northwest-trending zone of structural disturbance (Smith and others, 1971, p. 31-33) later discovered by ERTS imagery and named the Tyrone-Mount Union lineament.

Smith and others (1971, p. 33) described the zone and its relation to mineralization as follows:

> Gwinn (1964) discussed the origin of Appalachian folds by movements along stratigraphically-defined detachment thrust faults, and found lineaments in the Appalachian Plateaus corresponding to the edges of semi-independent thrust blocks. The northwest-trending zone passing through the Hares Valley area seems reasonably attributed to a similar process, in view of its location where fold trends change. The additional stresses and strains at this junction of advancing thrust sheets are inferred to have produced the northwest faulting, fracturing and fold termination necessary to allow increased permeability for circulation of metal-bearing fluids. This zone and others like it seem favorable for additional metal concentrations.

Occurrence No. 1 contained sphalerite, galena, and muscovite along joints which trend N55-60W, 67-72NE. Slickensides in similar planes trend N52-55W and plunge 2-22SE. Joints with limonite gossan trend N19W, 88SW and N58W, 77SW. Possibly, muscovite with a clear paragenetic relation to the sulfides could be found and used for a K-Ar date, sorely needed to date hydrothermal activity in the Appalachians. Elsewhere in the quarry, a few hundred pounds of limonite gossan float appears to have come from min-

eralized joints-veins which trend N21W, 84SW where bedding is N47E, 48NW.

Occurrence No. 2 consists of a few hundred tons of limonite gossan boulders over a 500 × 100-foot (150 × 30 m) zone avoided during ganister quarrying operations (Smith and others, 1971).

Occurrence No. 3 consists of a 25-foot- (7.7 m) long, 9-foot- (2.8 m) wide, 5-foot- (1.5 m) deep trench with a 37-inch (95 cm) diameter poplar tree growing in it. The exposed gossan plus breccia zone is 5 feet (1.5 m) wide, but this includes about 1 foot (30 cm) of barren quartzite. Gossan veins trend N58E, 81NW, and bedding is reported to trend N25E. This gossan was reported to contain 10 ppm Hg and the A_0 soil was similarly, extremely rich in mercury (J. M. McNeal, personal commun., 1971).

Occurrence No. 4 consists of a 6-foot- (1.8 m) wide, 12-foot- (3.7 m) long, 8-foot- (2.4 m) deep pit with a long axis of N60W. Irregular gossan zones are only up to about 2 inches (5 cm) thick, and there is only minor quartzite breccia over about a 5-foot- (1.5 m) thick E-W zone. A limonite vein near the pit trends about N10W, 80W and bedding near the breccia zone trends N10W, 75E.

Occurrence No. 5 consists of sparse sphalerite and galena as disseminations and veinlets in pyritic Tuscarora quartzite float boulders weathered to a greenish-yellow color. Sphalerite from this occurrence was found to contain 20 ppm Hg versus 0.19 and 0.62 ppm for sphalerite from occurrences 7 and 9, respectively.

Occurrence No. 6 was described in detail by Smith (1974), and will only be summarized here, except for the core logs. Plate 5a shows the bedding and probable fault traces. The local controls on mineralization are two small faults with 55±10 feet (17±3 m) displacement in a horizontal direction with westward movement on the south sides relative to the north. Based on limited exposures about 20 feet (6 m) northeast of the drill collar and 210 feet (64 m) southeast of the drill collar, the faults are assumed to be steeply dipping.

The Tuscarora Formation at Occurrence No. 6 consists of quartzite beds from ½ inch (1 cm) to 12 inches (30 cm) in thickness separated by silty shale laminae, often containing arthrophycus. The Rose Hill Formation consisting of fissile gray (fresh) to buff (weathered) shales which contain fossil tentaculites (A. Guber, personal commun., 1972), trilobites, etc., and contains a few thin quartzite beds near the faults. The first few feet of Rose Hill shale northwest of the fault is moderately mineralized with pyrite and sphalerite.

It was initially planned to determine the attitude of the faults by diamond core drilling, but only 20 (6 m) of the 200 (60 m) feet contracted was received. The drill core was oriented S55E with a dip to the southeast of 45°.

The drill core was logged as follows:

Feet	Meters	
0-2	0-0.6	Thoroughly brecciated quartzite. Fragments are from 1/4 inch (0.5 cm) to 1 inch (3 cm). Matrix of pyrite, dark sphalerite, minor orange-brown sphalerite and galena. Dark sphalerite most abundant in bottom 4 inches (10 cm). No significant amount of shale or carbon-rich insoluble residue. Breccia fragments are subangular and often equidimensional.
2-8	0.6-2.4	Brecciated quartzite with black-shale chips and insoluble residue. Most of matrix is quartz and black insoluble residue rather than pyrite as above. Most of sphalerite is orange brown. Three-fourths inch (2 cm) galena occurs at 5.25 feet (1.6 m) and many thinner galena veinlets are present down to 6 feet (1.8 m). One inch (3 cm) of galena at 7 feet (2.2 m). Scattered galena, pyrite and sphalerite occur throughout, galena and sphalerite appear to replace pyrite in matrix.
8-11.1	2.4-3.4	Slightly fractured quartzite with black-shale layers and chips. The fractures are mostly 1/16- to 1/8-inch (1-3 mm) wide and mineralized with orange sphalerite and galena. These fractures are from one half inch (1 cm) to approximately 4 inches (10 cm) apart. At 10 feet (3.0 m) there is a black-shale lamina which makes an angle of 45° to core axis. From 10.25 feet (3.15 m) to 10.75 feet (3.3 m) there is a rich zone of pyrite, orange sphalerite, dark sphalerite and trace galena.
11.1-21.7	3.4-6.6	Quartzite with abundant black-shale laminae and a few minor fractures and breccia zones. Hair to 1/32-inch (1 mm) wide fractures with orange-brown sphalerite are spaced approximately every 6 inches (15 cm) apart on average. At 17 feet (5.2 m) there are a few quartz crystal vugs with orange-red sphalerite crystals perched on the quartz crystals. From 20.5 feet (6.4 m) there is quartzite breccia with red-orange to brown sphalerite in matrix. This 6-inch (15 cm) zone is estimated to contain 1-2% Zn. Galena was not observed. Shale laminae make angles with the core axis of 20°, 25° - 30°, and 35°. Two 1/32-inch (1 mm) chalcopyrite grains in vugs were noted.

If one assumes that the 11.1-foot (3.38 m) ore intercept is through a tabular breccia body which strikes approximately perpendicular to the drill core axis and dips 75NW, the "true" ore thickness becomes 10 feet (3 m). If such a tabular body is assumed to have a length of 50 feet (30 m) (during site preparation it was observable for about this distance) and continue 50 feet (15 m) downdip, the body would contain 2.5×10^4 short tons (2.3×10^4 metric tons) of ore. Based on the 11.1-foot (3.38 m) intercept containing (see assays from which this weighted average was obtained) 2.94% Zn, 6.02% Pb, 0.04% Cu, 0.45 oz Ag/ton, and 0.006 oz Au/ton, this tabular body would contain 7.5×10^2 tons Zn, 1.5×10^3 tons Pb, 1.0×10^1 tons Cu, 1.1×10^4 oz Ag and 1.5×10^2 oz Au. Obviously, the total amount of "ore" is highly uncertain with only one shallow drill hole which essentially bottomed in 1-2% Zn (visual estimate). Such "ore" would, however, have a Zn-Pb-Cu-Ag-Au value of $57/ton (at 1974 prices), mainly from the zinc and lead.

The Albert Burkhart (a resident of central Pennsylvania) exploration pit trench (Plate 5a), apparently dug during the 1950's, appears to have been located in barren Rose Hill Formation shale in search of the source of mineralized quartzite float which originated farther uphill. The long axis of the trench is N53E and the length and width at the rim are 65 feet (20 m) and 15 feet (4.6 m), respectively. At normal water level the trench is 48 feet (12 m) long and 12 feet (3.7 m) wide. The average depth is 6 feet (2 m) and the maximum 8 feet (2.5 m). The trench predates the geochemical study of Smith and others (1971), but was kept secret by Burkhart until after that publication. Thus, the discovery of this occurrence is an indirect result of the stream sediment program of Keith and others (1967), and not from the trench.

Occurrence No. 7 consists of a well exposed section of Tuscarora quartzite with an apparent stratigraphic thickness of 696 feet (212 m). Because the Tuscarora at Occurrence No. 9 is 593 feet (181 m) thick, some structural thickening is likely at Occurrence No. 7. Bedding in the exposure is variable, but seems to average about N15E, 85W. Galena and sphalerite-bearing veinlets have a variable orientation, but seem to average N65-70W, 80S. Thus, the veinlets are subnormal to bedding as described in an unpublished description by A. W. Rose (The Pennsylvania State University, 1970). H. W. Schasse (thesis, in prep.) separately describes the details of the structure. The lowest 200 feet (60 m) of the Tuscarora contains a few tenth's of a percent sphalerite and galena and the next hundred feet above, about a percent disseminated pyrite. This sulfide-bearing portion of the section also seems to contain the most clay, silt and carbonaceous material.

The assays of chip samples reported by Smith and others (1971) could be substantially low for zinc because of leaching of sphalerite by acid ground

water and almost certainly have a substantial sampling error. The eastern end of the mineralized zone contains a more typical yellow-orange-colored disseminated sphalerite with possible replacement textures and selected samples are estimated to contain a few percent zinc. Because somewhat richer mineralization is present here east of the covered zone, additional sampling via shallow vertical and west dipping diamond drill cores is recommended. The richest piece of galena was found as float in soil west of the covered interval.

Occurrence No. 8 consists of thin mineralized joints with trace galena, chalcopyrite and tetrahedrite near the northeast end of the quarry, and ruby-red sphalerite in a vuggy breccia zone near the middle of the quarry. The thin mineralized joints are vertical and trend N60W. Bedding here trends N23E, 61NW. The sphalerite breccia zone, estimated to be only a few feet (about a meter) wide appears to be roughly perpendicular to bedding which trends N23E, 62NW. Pyrite as disseminated grains, ovid nodules up to 2 inches (5 cm) of granular pyrite and as small crystals along joints, is common in much of the quarry.

The tetrahedrite may represent the source of arsenic in stream sediments in the area. The red color of the sphalerite also suggests possible arsenic in that mineral.

Occurrence No. 9, the Scrub Run quarry occurrence consists of minor amounts of reddish-brown sphalerite with galena and quartz in thin veins cutting impure, upper Tuscarora quartzite. These veins, up to about ¾-inch (2 cm) thick trend N42W, 55NE where bedding trends N23E, 57NW. The 50 to 100-foot- (15 to 30 m) thick zone which contains the veinlets overlies a portion of the Tuscarora which appears to have been reducing. Horizontal worm tubes *(Arthrophycus alleghenyensis)* in shale layers, carbonaceous matter and both disseminated and 1- to 3-inch ovid masses of fine-grained pyrite are common in the zone below the veinlets.

Occurrence No. 10, the Richard Hammon mine, was reported to consist of a 30-foot (9 m) drift to the south, and then about 200 feet (60 m) of drift to the west. It was last examined by Hammon 35 years ago. There was a turntable for the mine car at the right angle bend, which was reported to be located at the contact between two types of rock (Richard Hammon, personal commun., 1973). R. Hammon reported that the vein was only ½-inch (1 cm) wide and consisted of a greenish "serpentine" (slickensided shale?) with disseminated shiny rounded silvery blebs which could be panned from the lighter vein rock. Mr. Hammon reported that the grains were soluble in nitric acid and yielded a blue-green solution which turned deep blue after precipitation of iron with ammonia. His attempts to reduce a metal with electrodes resulted in loss by volatilization. Based on the presence of high arsenic in stream sediment sample 4076 and tennantite at

Occurrence No. 8, it seems possible that the metallic mineral was tennantite, enargite, or another copper sulfarsenide. Without accessible specimens, however, this is speculative.

The dump for the Richard Hammon mine is 40 feet (12 m) long on top, an average of 12 feet (3.7 m) high, 18 feet (5.5 m) wide, and is 25 feet (7.6 m) from the far end of the dump top to the base end at an angle of 35°. The approximate volume of this dump is 8,640 ft^3 (240 m^3), and would contain on the order of 520 tons. This would be sufficient for about 260 feet (80 m) of drifts with a 5 by 6-foot (1.5 × 1.8 cm) cross section, assuming 10% dump porosity. The long axis of the dump trends N19E and the cave-in above the mine entrance is 8 feet (2.4 m) wide and 20 feet (6 m) long. The relative abundance of Tuscarora to Juniata Formation rock on the dump is $^3/_4$ to $^1/_4$, and the Tuscarora quartzite contains an estimated 0.5 to 5% pyrite.

Occurrence No. 11, probably of the same vintage of prospecting as Occurrence No. 10, now is observable only as a caved-in adit about 10 feet (3 m) above road level. A soil sample collected around the entrance was low in most base metals, but possibly high in arsenic and mercury (Smith and others, 1971). Possibly, some of the mercury could be from detonating agents used in mining. Norman Bucker of Mudtown reported to Richard Hammon that about 50 years ago there was a wooden door on the adit with an oversized iron padlock. Several tons of quartzite with disseminated pyrite occur just below the road.

Occurrence No. 12, the first prospect of three to be relocated on Silver Mine Knob (Smith and others, 1971), consists of a 7 by 15-foot (2.2 by 4.6 m) pit (at the bottom) with a maximum depth of 15 feet (4.6 m). As shown in Figure 78, the limonite gossan veins trend approximately perpendicular to the ridge and bedding strike. No historical data are available, but a 10-inch- (25 cm) diameter yellow birch growing in the pit suggests the pit is probably well over 25 years old. Soil sample numbers 46 to 50, and stream sediment sample numbers 4078, 4080, and 4072 of Smith and others (1971) suggest more substantial amounts of zinc and lead to the west and northwest. These anomalies may be related to the N30W crossfault on the southwest side of Silver Mine Knob. Tectonic breccia from the southeast end of the fault on the ridge crest was found to contain 0.13% arsenic.

Occurrence No. 13 consisted solely of two masses of nearly pure, finely crystalline pyrite from the pipeline trench. Stream sediment sample number 4074, collected just downhill from the pyrite, shows that there may be substantial zinc mineralization in the immediate area.

Occurrence No. 14, the Peter Hammon-George Schaeffer "Gold Mine," consists solely of a small pit about 10 feet (3 m) in diameter and now about 6 feet (1.8 m) deep. This pit excavated a slightly brecciated gray to salmon crystalline dolomite with traces of chalcopyrite and pyrite. A stream sedi-

ment sample collected downstream on the creek which flows west to east about 20 feet (6 m) south of the mine was found to contain background amounts of zinc, copper and silver. Other pits in this area appear to have been dug for "fossil iron ore."

The zinc-lead occurrences in Hares Valley appear to be similar to those of the Wurtzboro, New York area (Sims and Hotz, 1951, and Moxham, 1972), as well as those in the Milesburg Gap area of Centre County, Pennsylvania.

The length of anomalous soil and stream sediment and water samples in the Hares Valley area is at least 12 miles (19 km), the limits of the area studied. Within this discontinuous zone there are few fresh exposures of Tuscarora quartzite without at least traces of sphalerite and/or galena. Based on the transport rate of streams draining the Tuscarora slopes and anomaly intensity, the total amount of zinc and lead leaving the area annually must be immense and could not be fed by the small veinlets now known without rapid depletion of the source. In many areas, the amount of replaceable pyrite in the Tuscarora may exceed 5 percent, suggesting that search for extensive zinc-rich massive pyrite blankets analogous to the pyrite blanket described by Heyl and Bozion (1971) at Port Jervis, New York (with ~1% Zn by semi-quantitative emission spectrograph analysis) appears warranted. Similarly, the breccia zones along moderate-sized faults do not seem to have received the exploration effort they deserve. Because the deposits do not fit the classical zinc deposit types known in the Appalachians, it will be difficult, however, to stimulate exploration in even this mining-oriented area.

Because of the variety of metals involved, "natural pollution" is already substantial in certain places in the Hares Valley area. Extra caution should be exerted in locating and testing public drinking water supplies. Unlike the presently-mined ore at Friedensville, the Hares Valley zinc is associated with substantial amounts of lead, arsenic, and mercury, suggesting that water testing should be comprehensive. Moxham (1972, p. 16-17) discusses hazards at the almost identical Schawangunk Mountain area in New York.

Areas which may contain mineralization similar to that in Hares Valley include Licking Creek near the Mifflin-Huntingdon County line and Blacklog Mountains near Meadow Gap, Huntingdon County. The Licking Creek anomaly consists of a resampled and reanalyzed stream sediment anomaly with anomalous zinc, nickel, and cobalt (4.7% Fe, 0.30% Mn, 66 ppm Cr, 50 Co, 80 Ni, 19 Cu, 204 Zn, 20 Pb, 2 Cd, <5 As, and <0.1 Ag). The anomaly

was found in the stream sediment survey of Keith and others (1967). Mr. Lou Emery (personal commun., 1973) reported lead mines along Licking Creek in this area. Richard Hammon reported mines in a hollow near the Bible to Youth Camp along Licking Creek. Richard Hammon, Howard H. Morgan, Lou Emery, and Ray Scranton McKean (personal commun., 1973) independently reported that Civil War veterans from the Shirleysburg area (named by McKean as Peter Burket, Thomas Harris, Gifford and Myers) mined lead somewhere on Blacklog Mountain. Wildcat Hollow was frequently mentioned as the possible site of the mine, but a stream sediment sample contained background amounts of zinc and lead (Co 20 ppm, 65 Ni, 75 Cu, 145 Zn, 40 Pb, 5 As, and <0.1 ppm Ag). The somewhat high nickel and copper may be from the Ordovician Reedsville shale which furnishes most of the sediment at the lower, sampled end of the stream. Kelley and Gifford Hollows, also mentioned as possible sites of the mine were not sampled. At the time of sampling, it was not known that Gifford was one of the lead miners. It should be noted here that all of the other occurrences described by Richard Hammon which the author attempted to find were located as described.

The possibility of zinc-lead occurrences on Blacklog Mountain near Meadow Gap is based on stream sediment anomaly 2384 of Keith and others (1967), and the report of H. D. Rogers (1858) of the "extraordinary cross fault, filled with iron ore," mined at the crest of the Blacklog Mountain, south of Orbisonia. Rogers (1858, p. 371) described the occurrence as follows:

> A deposit of iron ore exists on the very summit of Blacklog Mountain, 4 miles S.W. of Orbisonia. It was first mined by M. J. Bell, and is no longer mined. The ore and clay in which it lies seems to fill a transverse fissure or cleft in the Levant white sandstone, at a point where there is a slight indentation in the crest of the mountain. It is a dark reddish brown variety of the hydrated oxide of iron, rather cellular and very ponderous, and abounds in masses, having the cylindrical or stalactitic structure-pipe ore. . . . It is probable that a similar fissure, with ore in it, exists in the neighborhood of the Meadow Gap, as fragments of ore have been observed on the surface there in a line crossing the mountain.

The site of the Bell mine which produced cellular, very heavy ore is probably in the notch located at latitude 40°10′35″ N, longitude 77°54′25″ W, but has not been examined.

35. MILESBURG GAP, CENTRE COUNTY

(Abandoned Zinc-Lead Prospects)

1. *Name:* Milesburg Gap area. Occurrence No. 1 may be part of the A. Brooks farm along Spring Creek. During the 1915 development, occurrences 1 and 6 were known as the Schad prospect.

2. *Location:* A. The original horizontal adit(s?) and sulfide dumps, occurrence No. 1 (the Schad prospect), are located 0.8 mile (1.3 km) south-southeast of the junction of Spring Creek with Bald Eagle Creek and 1.2 miles (1.95 km) west of the summit of Trcziyulny Mountain, Boggs Township, Centre County. This adit was driven into Bald Eagle Mountain on the east side of Pa. Route 144 (see Plate 5b).

Occurrence No. 2, a small pit found during the present study, is located in Boggs Township 200 ± 100 feet north of the crest of Bald Eagle Mountain, 1.1 miles (1.75 km) southeast of the junction of Spring Creek with Bald Eagle Creek and 0.5 mile (0.8 km) north-northwest of the summit of Trcziyulny Mountain.

Occurrence No. 3, found by David C. Herrick (personal commun., 1972), is located in Boggs Township at an elevation of 1200 ± 100 feet on the northwest side of Bald Eagle Mountain, 0.2 mile (0.35 km) southeast of an unnamed reservoir for the city of Milesburg. This reservoir is 0.55 mile (0.9 km) north-northeast of the summit of Trcziyulny Mountain.

Occurrence No. 4, found by Herrick (personal commun., 1972), is located in Boggs Township at an elevation of 1250 ± 100 feet (380 ± 30 m) on the north slope of Bald Eagle Mountain, 0.45 mile (0.75 km) southwest of Interstate Route 80 and 1.2 miles (1.9 km) northeast of the summit of Trcziyulny Mountain. Krohn (1976) found additional mineralization 900 feet (280 m) to the east.

Occurrence No. 5, reported by Smith and others (1971), is located in the center and east side of the roadcut of Interstate Route 80 through Curtin Gap, 1.0 mile (0.6 km) northwest by road from the Pa. Route 26 exit, Boggs Township.

Occurrence No. 6, found by Herrick, is located in Boggs Township at an elevation of 1270 ± 50 feet (385 ± 15 m), 1750 feet (540 m) N30W of the crest of Trcziyulny Mountain and 1800 feet (550 m) S31W of the Milesburg Reservoir.

Occurrence No. 7, found by Hsu (1973) as a barite location and then by the author as a lead occurrence by following up on Hsu's geochemical data, is located near the upper end of a scree slope on the northeast side of Lamb's Gap at an elevation of 1380 feet (425 m). This is located 3500 feet (1065 m) southeast of old U. S. Route 220 and 7425 feet (2265 m) S47E of Bullit Run beneath new U. S. Route 220, Howard Township (see Plate 5b).

Occurrence No. 8, found by Krohn (1976), is located on the crest of Bald Eagle Mountain in Boggs Township at an elevation of 1450 feet (440 m), 3100 feet along the ridge northeast from the west-bound lane of Interstate Route 80. This is 4400 (1,340 m) feet northwest of Interstate Route 80 over Pa. Route 26 and 4850 feet (1,478 m) S80E of the Curtin 868 triangulation station.

Occurrence No. 9, found by Hsu, is located on the Boggs-Spring township line at an elevation of 1700 feet (518 m), 6250 feet (1905 m) N87W of the junction of Buffalo Run and Spring Creek. This is 5500 feet (1675 m) S19E of the intersection of Pa. Route 144 and U. S. Route 220.

In addition to these occurrences near Milesburg Gap, A. V. Heyl (U. S. Geol. Survey, personal commun., 1972) reported that P. D. Krynine of The Pennsylvania State University found galena and barite in veinlets through lower Tuscarora quartzite on the northeast end of the roadcut of U. S. Route 322 through Bald Eagle Mountain, at Skytop about 15 miles (24 km) southwest of Milesburg. Heyl himself found barite veinlets in the Juniata Formation at Skytop. Several hundred feet southeast along the same road, the present writer observed major amounts of finely crystalline pyrite and drusy quartz in Bald Eagle sandstone, but he could not relocate the original galena location. To the east, Illsley (1955, p. 31) found anomalous amounts of heavy metals in stream waters in "Zinc Run" flowing southeast from Waddle Gap into Buffalo Run. [More significantly, perhaps, Illsley found that the heavy metal content of the stream water decreased substantially following rainfall.] Herrick (personal commun., 1972) reported rumors of one "lost" lead mine in the Lamb's Gap area and a second on Nittany Mountain above the village of Zion.

B.

	LATITUDE N	LONGITUDE W
1	40° 55′ 52″	77° 47′ 03″
2	40° 56′ 00″	77° 46′ 18″
3	40° 56′ 26″	77° 45′ 26″
4E	40° 56′ 48″	77° 44′ 39″
4W	40° 56′ 47″	77° 44′ 10″
5	40° 56′ 52″	77° 44′ 10″
6	40° 56′ 13″	77° 45′ 52″
7	40° 58′ 33″	77° 41′ 40″
8	40° 57′ 16″	77° 43′ 47″
9	40° 55′ 14″	77° 48′ 30″

C. TOPOGRAPHIC MAP: Occurrence Nos. 1, 2, 3, 6, and 9 are on the Bellefonte 7½-minute quadrangle and occurrence Nos. 4, 5, 7, and 8 on the Mingoville 7½-minute quadrangle.

3. *Host Rock:* Tuscarora Formation of lower Silurian age. Occurrence No. 1 is 240 ± 25 feet (75 ± 8 m) stratigraphically below the first outcrop of Rose Hill shale and 415 ± 25 feet (128 ± 8 m) stratigraphically above the first outcrop of Juniata redbeds, limiting the thickness for the Tuscarora here to ≤660 feet (200 m). Because the thickness of the Tuscarora quartzite plus Castanea sandstone in this area is known to be approximately 450 feet (140 m, only approximate because of color change problems), this limits the occurrence to the upper half of the Tuscarora. Similarly, unpublished reports by visitors to the Schad prospect (occurrence No. 1) mention one reddish sandstone bed in the adit. Float of Castanea sandstone just northwest of the main adit suggests, but does not prove, that the mineralization at occurrence No. 1 is in the top 100 feet (30 m) of Tuscarora quartzite. No fossil worm tubes were observed on the adit dump proper, suggesting that the adit was probably not in Castanea sandstone. The adit dumps are composed of approximately one-third clay, suggesting that the Tuscarora was probably very shaly here.

Occurrence Nos. 2, 3, and 4 are in Tuscarora Formation, probably upper, but there is no outcrop. Occurrence No. 5 occurs 110 feet (34 m) stratigraphically above the uppermost red sandstone (this red sandstone being variously considered lower Tuscarora or upper Juniata Formation). In any case, occurrence No. 5 is in lower Tuscarora Formation. Occurrence No. 6 is in the upper Tuscarora or Castanea quartzite, within a few feet of the Rose Hill shale. Occurrence No. 7 is probably in upper Tuscarora quartzite. Occurrences Nos. 8 and 9 were not examined, but are probably in Tuscarora quartzite.

4. *Estimated Total Amounts of Ore Metals:*

A.

Occurrence	<1 g	1-1000 g	1-1000 kg	>1000 kg
1			Cu, Ag	Zn, Pb, Ba
2		Ba, Ag	Pb, As, Cu	
3			Pb, Ba	
4		Pb	Ba, As	
5	Cu	Zn, Ba		
6		Ba, Zn(?)		
7			Pb, Zn, Ba	
8	Ag	As	Pb	
9			Pb	

B. ASSAYS: Butts and Moore (1936) reported 0.3 oz Ag/ton in "promising looking specimens" from occurrence No. 1. The author's visual estimate of the grade of rock beneath the surface of this dump is 1-2% Pb plus Zn, 0.5% barite, and 3-5% pyrite. An experienced economic geologist visiting the property in 1915 reported that the back 15 feet (5 m) of the adit was composed of 2-3% combined sphalerite and galena, plus moderate amounts

of barite. The unpublished analyses listed below are reported to represent the ore zones exposed in 1941. Analysis (5) is definitely on high-grade samples and the others probably so. Analysis (1) is reported to be from near the entrance to a second, unobserved adit.

	(1)	(2)	(3)	(4)	(5)
Zn%		6.8	11.4	8.8	12.9
Pb%		1.4	.8	1.2	24.0
Cu%	0.8				
Ag oz	0.1	0.5		.01	
Au oz	0.01				
SiO_2%			12.1[1]	71.6	45.6
Al_2O_3%				.2	.6
Fe_2O_3%			2.8[1]	1.5	1.7[1]
S%			7.6	4.1	7.0

Limonite-quartzite chip composite samples collected by the author, M. D. Krohn (1976), and others, were analyzed by the Pennsylvania Geological Survey and others, as follows:

Occurrence	Pb%	Zn ppm	Co ppm	Ni ppm	Cu ppm	Ag ppm	As ppm
2	0.62	115	5	15	950	1	5000
3[a]	0.96	28	N.A.	5	295	N.A.	N.A.
4	.07	105	5	5	255	.1	500
6[a]	.06	88	N.A.	N.A.	170	N.A.	N.A.
7[a,b]	.00	16	N.A.	5	8	N.A.	N.A.
8	0.30	55	15	5	110	0.5	340
9[a]	0.16	35	N.A.	21	32	N.A.	N.A.

a. Sampled and analyzed by Hsu (1973).

b. A stream sediment sample collected 1750 feet (540 m) northwest of this occurrence contained 980 ppm Zn, 19 Pb, 9 Cu, 71 Ni, 87 Co, 0.04 Ag, and 12 ppm As.

N.A. Not analyzed.

Lenker (1962) found that a sample of sphalerite from Occurrence No. 1 contained 0.74% Fe, 96 ppm Cu, 580 ppm Cd, 41 ppm Ge, and 62 ppm Ga.

5. *Minerals Observed and Relative Amounts:*

A. ECONOMIC

Occurrence	Major	Minor	Trace
1	Sphalerite (dark to orange-brown), galena		Pyromorphite[2]

1. Possibly reported as the elements.
2. Reported by Butts and Moore (1936, p. 103).

	2	"Limonite" (0.6% Pb)		
	3	"Limonite" (1% Pb)		
	4			
	5			Sphalerite (yellow-orange) and chalcopyrite (tetrahedrons)
	6		Sphalerite(?)[3]	
	7		Corkite * (olive, finely crystalline coatings on drusy quartz)	"Hinsdalite-Ba"* (white, procelain-like masses)
	8			
	9			
B. GANGUE				
	1	Quartz, pyrite and barite	Native sulfur* (pale) yellow coatings with sphalerite	
	2	Quartz		Barite
	3	Quartz	Barite	
	4	Quartz	Barite, limonite	
	5	Quartz (drusy crystals)	Barite (sky-blue crystals and white cleavages)	
	6		Limonite	Barite
	7		Barite, limonite	
	8	Limonite		
	9	Limonite	Barite	

6. *Paragenesis:* For occurrence No. 1: tectonic brecciation, pyrite and quartz; galena, sphalerite, and barite.

7. *Geologic Description:* Occurrence Nos. 1 through 9 are located on the steeply-dipping, northwest limb of the Nittany Arch (anticline) near the southeast edge of the Allegheny Plateaus.

Rose Hill shale 240 feet (74 m) northwest of the main adit at occurrence No. 1 strikes N76E and dips 70N. Tuscarora quartzite 435 feet up the hill to the northeast of the adit strikes N79E and dips 80N. Ripple mark troughs here plunge $22 \pm 2°$ to the east. Juniata Formation redbeds 440 feet southeast of the adit strike N68E and dip 67N. The long axis of the adit entrance and caved-in area uphill from it is N80 $\pm$ 2E, suggesting that the mineralized zone was following bedding. Both the Tuscarora and Juniata to the south of

3. Mr. Schad reported considerable blende, but none was observed during the present study.

the adit are covered with thin bluish coatings of calcite* (D. C. Herrick, personal commun., 1972).

The horizontal adit at occurrence No. 1 (Schad prospect) is caved-in about 8 feet (2 m) from the entrance where wood timbering in the roof has fallen in (Figure 79). A second reported adit has not been located. In 1915, the main adit was reported to be about 35 feet (11 m) long, and Butts and Moore (1936) report that it was 50 feet (15 m) long. The main adit was re-opened in about 1938-1941 and some additional prospecting done (A. V. Heyl, personal commun., 1976). Illsley (1955, p. 26) reported that the drift was reopened and extended during the summer of 1954. This agrees with the present estimated dump volume. The entrance dimensions suggest that the adit itself was 5 feet high, and on an old map, 4 feet (1.5 m) wide. At present, the dump appears to be approximately 45 feet long, 20 feet wide, and 6 feet deep ($14 \times 6 \times 1.8$ m), yielding a volume of 5,400 cubic feet (150 cubic m) or approximately 400 tons. Assuming 10% dump porosity, this suggests that the adits were a total of 245 ± 50 feet (75 ± 15 m) long. This is in excellent agreement with the recently obtained sketch map of the adits

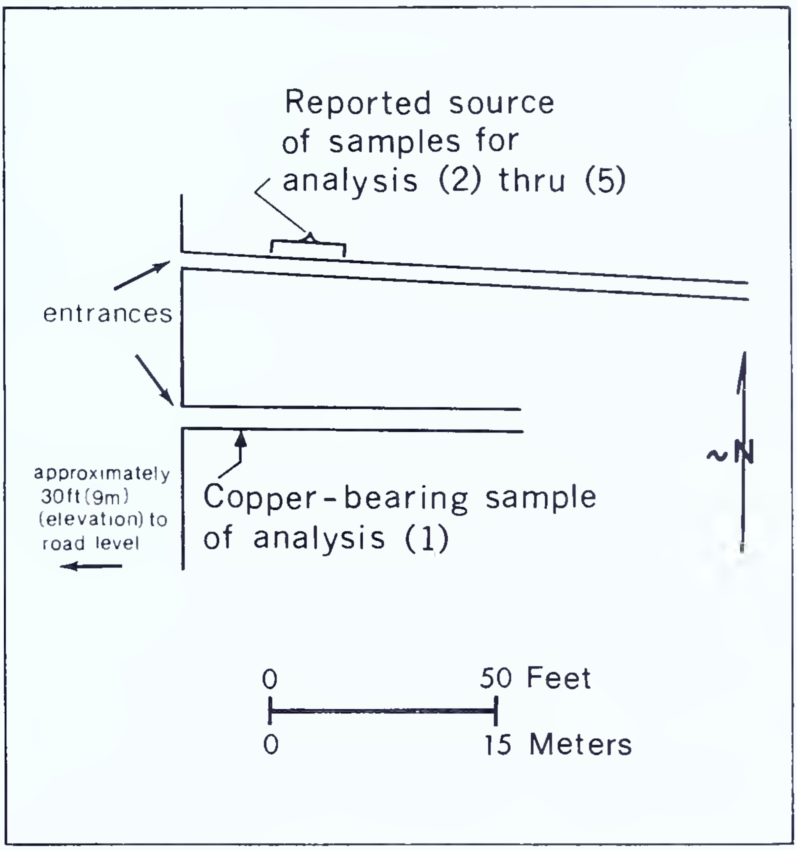


Figure 79. Plan view of occurrence No. 1 (Shad prospect) Milesburg Gap, Centre Co. (from unpublished mine report).

(Figure 79). An economic geologist visiting the Schad prospect in 1915 reported that the back 15 feet (5 m) of the 35-foot-long adit contained an average of 2-3% combined galena and sphalerite in addition to moderate amounts of barite. Although Butts and Moore (1936) also mentioned some mineralization along bedding planes, they state that the vein was 6 inches (15 cm) wide and cut diagonally across bedding.[4] Although only a few pieces of ore-grade rock (Zn plus Pb estimated to be greater than or equal to 4%) were found on the dump by the present author, the 6-inch vein described by Butts and Moore (1936) would be inadequate to account for the sulfides observed on the dump. Additional low-grade zinc-lead mineralization must have been present. Illsley's water anomaly and report of geophysical anomalies at station M-1 (1955, p. 27), from a spring in the railroad cut on the west side of Spring Creek opposite the adit and McCoy's dam, suggests that the same or similar mineralization continues to the west side of the gap.

There are numerous (>10) pits and trenches in the area of occurrence No. 1, but it was not possible to distinguish those dug for base metal exploration from those for ganister and canal rock operations. Indeed, Butts and Moore (1936) described occurrence No. 1 (of the present report) as being in a ganister quarry. Also, the hill above the adit is terraced. Minor amounts of barite occur for the first 750 feet (225 m) by foot uphill from the adit and then no more until 4050 feet (1220 m) (by foot from the adit along the ridge crest) where a small amount occurs on slickensides.

Occurrence No. 2 consists of limonite gossan in tectonic breccia blocks around a small vague pit and a trail of similar blocks to the south. Only trace barite was observed and the scree slope to the northwest is relatively free of limonite. Most of this not-very-sharp ridge is Tuscarora quartzite with abundant cavities from shale chips. The extreme southeast side of the ridge is held up by red Tuscarora or Juniata Formation in places.

Occurrence No. 3 consists of barite and limonite in tectonic breccia blocks or on slickensides. Although uncertain because of the slope and ganister removal, this occurrence appears to be a narrow, northwest-trending fault zone which is several hundred feet long. There is no outcrop along this zone, but 900 feet (275 m) to the east-southeast, the Juniata sandstone exposed in the creek bed strikes N48E and dips 69N suggesting that there are major faults cutting Bald Eagle Mountain. Hsu (1973) has found that the stream to the northwest is strongly anomalous in lead and zinc.

Occurrence No. 4 was described by Herrick (personal commun., 1972) as consisting of several tons of brecciated quartz containing traces of barite. Krohn (1976) found similar material at the head of the scree slope to the east.

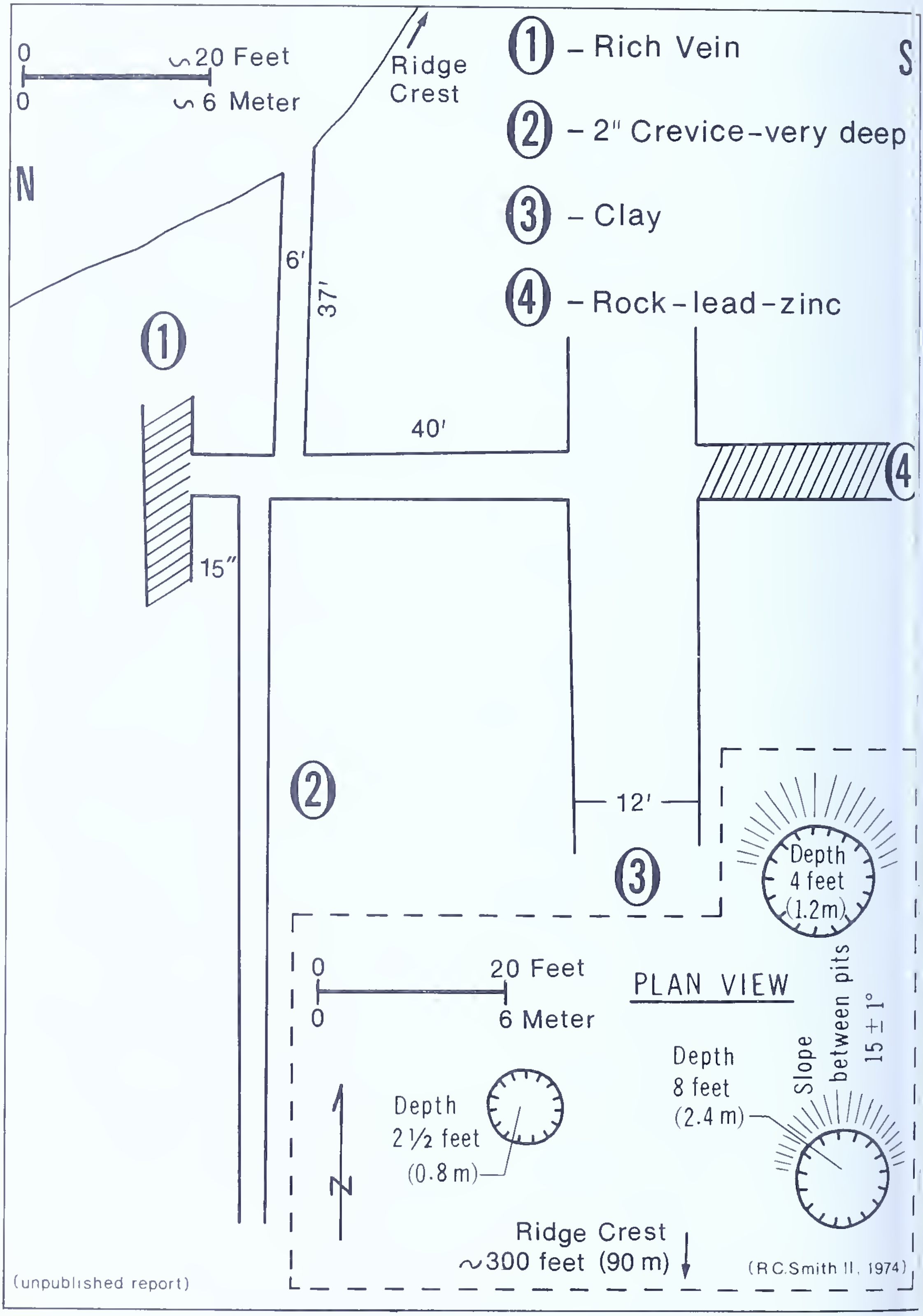
4. A. V. Heyl (personal commun., 1976) entered the mine during the 1930's and observed that the "ore" was in the crosscutting and bed-parallel veinlets in a nearly vertical fault, subparallel to bedding in nearly pure quartzite.

Occurrence No. 5 consists of mineralization along a small fault (now obscured by slumping) through Tuscarora quartzite containing abundant dark-gray sulfurous smelling shale beds. The Tuscarora at this location strikes N60E and dips 84S, indicating that it is overturned. In the gully-creek between the eastbound and westbound lanes, there is a slickensided surface in the Tuscarora which trends N45W and dips 50NE. Bedding here strikes N55E and the dip is 90°. Tonoloway limestone 2800 feet (580 m) to the northwest strikes N54E and dips 68N. Some of the Tonoloway is brecciated, and there are abundant vugs with calcite crystals and traces of pale-blue fluorite. (Fluorite and phosphate fertilizers may account for the fluorine anomalies in the water wells of Bald Eagle Valley.) This vuggy and brecciated Tonoloway would likely be a fair lead-zinc host to mineralizing solutions escaping the Tuscarora.

Occurrence No. 6 was described in unpublished industrial reports as consisting of a vertical shaft of a 5 × 5-foot (1.5 × 1.5 m) cross section through 37 feet (11 m) of lower Rose Hill shales. A drift to the southeast from the bottom was reported to be about 2 × 3 feet (0.6 × 0.9 m) in cross section and about 52-feet (16 m) long (see Figure 80, a cross section of prospect 6 for Mr. Schad and a plan map by the author). The last two feet of the drift to the southeast was reported to cut red sandstone (Castanea?). The bottom 5 feet (1.5 m) of the shaft and throughout the drift, the rock was pyritic. Most of the pyrite was in layers parallel to bedding, but some occurred in crosscutting veinlets. The richest pyrite occurred near the shale-sandstone contact and in the floor of the drift. Bedding in the prospect was reported to trend N50E, 86S.

The north dump is estimated to have a volume of 1200 ± 50 cubic feet (34 ± m^3) from its dimensions of 20 × 10 × 6 feet (6 × 3 × 1.8 m). Such a dump would weigh about 120 tons (110 metric tons) and could have resulted from on the order of 37 feet (12 m) of workings with an average cross section of 25 feet square (7.5 m^2) plus 52 feet (16 m) with an average cross section of 6 feet square (.56 m^2). This is consistent with the unpublished cross section.

Occurrence No. 7 is located primarily in the head of a scree slope with no outcrop. Minor amounts of limonite and barite occur along fractures in quartzite float boulders and traces of corkite and hinsdalite on drusy quartz-coated fractures. The base of the scree slope was obviously excavated, but the purpose of the excavations and possible underground extension are uncertain. Although only supergene (oxidized) lead minerals were found on the scree slope, stream sediment samples by Hsu (1973), and later the author, are highly anomalous for zinc (Hsu: 535-1600 ppm Zn, author: 980 ppm Zn) and only background for lead (35-40 ppm Pb vs. 19 ppm Pb). This appears to be a classic example of the less soluble lead remaining behind in a silica rock as secondary minerals and zinc dissolved in the ground water. At the site of mineralization, decomposition of pyrite produces acid,



0 20 Feet
0 6 Meter
Ridge Crest
① – Rich Vein
② – 2" Crevice–very deep
③ – Clay
④ – Rock-lead-zinc
S
N
6'
37'
40'
15"
12'
Depth 4 feet (1.2m)
0 20 Feet
0 6 Meter
PLAN VIEW
Slope between pits 15 ± 1°
Depth 8 feet (2.4 m)
Depth 2 1/2 feet (0.8 m)
N
Ridge Crest ~300 feet (90 m)
(unpublished report)
(R.C.Smith II, 1974)

Fe^{2+}-rich ground water. After passing over several riffles in the creek and becoming oxygenated, Fe^{3+} hydroxides precipitate as copious "yellow boy" which absorbs zinc from solution. Thus, the water and sediment anomalies will show an inverse relation, limiting the usefulness of a single type of sample in follow-up geochemical surveys.

Hsu (1973) found that the sediment anomaly did not extend southeast past Lamb's Gap. Thus, based on Hsu's geochemical data and the apparent rapid rate of sediment transport, there must be a relatively large source of heavy metals in the Lamb's Gap area. A southeast-trending row of B- zone soil samples from old U. S. 220 to the base of the scree slope is recommended to test for the possibility of zinc in limestones stratigraphically above the Tuscarora Formation.

Occurrence No. 8 was recently relocated by Krohn (1976), and has not been examined by the author. Krohn (personal commun., 1976) has furnished a tape and compass map of the open pits, presented here as Figure 81, and the limonite sample for the analysis listed in part 4 above.

Occurrence No. 9 was located by Hsu (1973, p. 24) during follow up of stream sediment sampling. He described thoroughly brecciated Tuscarora quartzite containing barite and limonite.

Other barite and limonite gossan(?) occurrences along Bald Eagle Mountain, but lacking proof of related zinc-lead mineralization, are described by Hsu (1973, p. 20-25) and Krohn (1976, p. 47-50). Hsu (1973) gives excellent geochemical data and statistical analysis for zinc, lead, copper, nickel, and barium in stream sediments and fluorine in stream waters for the Bald Eagle Mountain area. Krohn (1976) describes various lineaments and fracture zones along Bald Eagle Mountain.

Lead was reported to have been mined some years before the American Revolution by the Cornplanter tribe of Indians (Linn, 1883, p. 256) from near the Treaster farm on "Bald Hill." The occurrence has not, however, been verified.

In summary, the available data suggest large quantities of zinc and lead in the area. Despite the lack of similar, known commerical deposits, geophysical exploration for thick pyritic blankets with associated base metals near the top of the Tuscarora Formation appears warranted.

Figure 80. Cross section and plan view of occurrence No. 6, Milesburg Gap area, Centre Co.

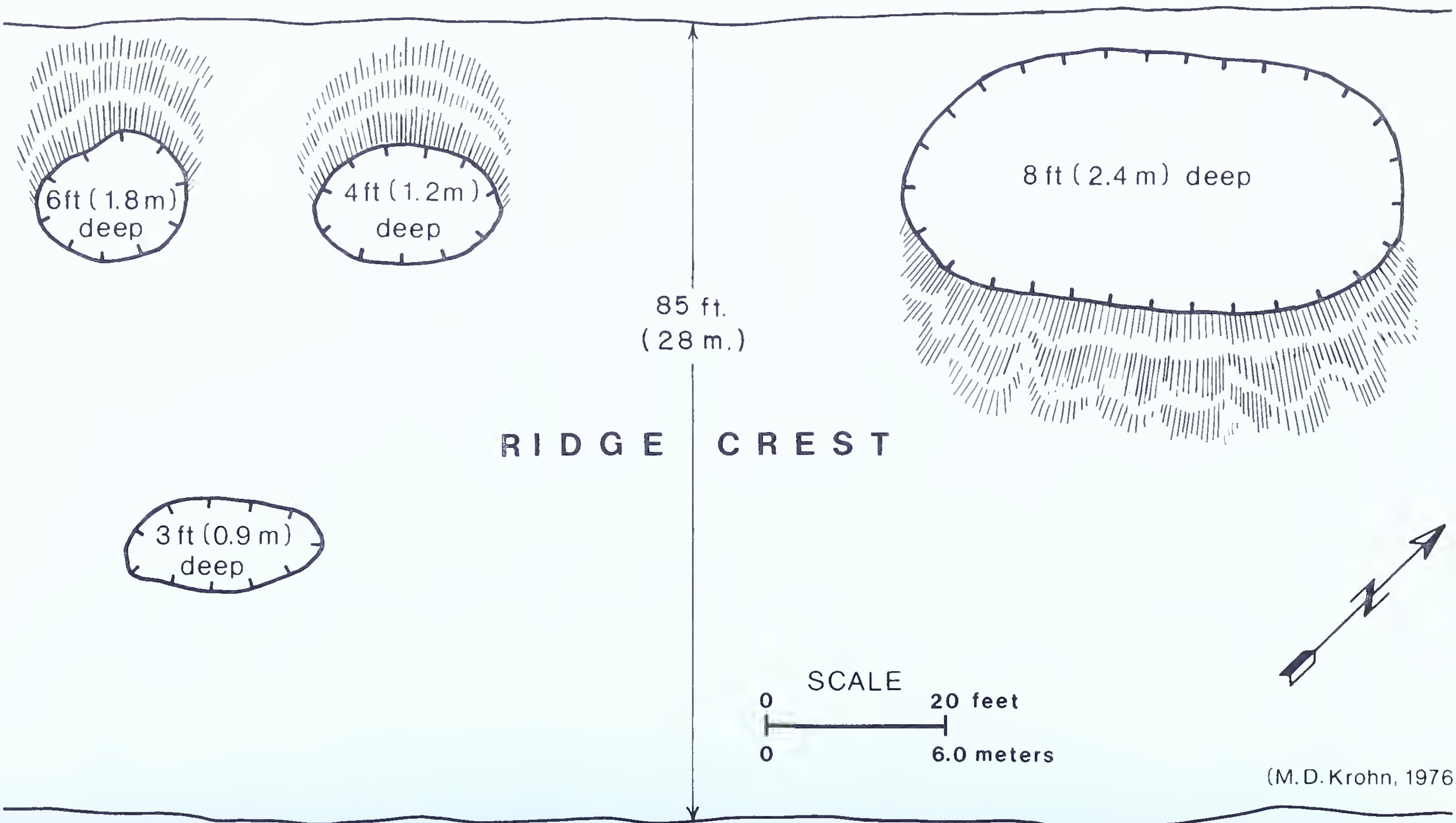


Figure 81. Open pits at occurrence No. 8, crest of Bald Eagle Mountain, Northeast of Curtin Gap, Centre Co.

DEVONIAN (CATSKILL FORMATION) OCCURRENCES

36. MILL RUN, BLAIR COUNTY

(Trace Lead Occurrence)

1. *Name:* Mill Run galena occurrence.

2. *Location:* A. The galena-bearing bed occurs on both sides of a roadcut halfway between the settlements of Red Hill and Mill Run, near Altoona. This roadcut is 0.5 mile (0.8 km) just south of east of the east end of the Mill Run Reservoir dam, 1.85 miles (3.0 km) west-northwest of the underpass of Pa. Route 36 beneath the ConRail (Penn Central) Railroad tracks in Altoona, and 0.6 mile (1 km) due north of the north end of Allegheny Reservoir. The mineralized bed intercepts the 1973 road level approximately 486 feet (150 m) downhill from a highway station marker 1/20, the location of which corresponds with the stratigraphically lowest exposed red bed. This roadcut is in Logan Township, Blair County.

B. LATITUDE N: 40° 31′ 04″ LONGITUDE W: 78° 26′ 28″

C. TOPOGRAPHIC MAP: Altoona $7\frac{1}{2}$-minute quadrangle.

3. *Host Rock:* Unpublished 15-minute compilation maps for the state geologic map edited by Gray and Shepps (1960) show that this area is underlain by the Devonian Chemung Formation; whereas the published map lumps several formations and refers to them all as undifferentiated Devonian marine. The mineral occurrence is probably best located with respect to the lowest exposed red beds, which generally have been used to define the base of the upper Devonian, non-marine Catskill or Hampshire Formations. (More recently, however, the Pennsylvania Geological Survey has considered the delta-front sands to be part of the Catskill Formation and has used them in some areas to define the base of the Catskill.)

4. *Estimated Total Amounts of Ore Metals:*

$<$1 g:
1-1000 g: Zn
1-1000 kg: Pb (probably less than 100 kg)
$>$1000 kg:

B. ASSAYS: None. Neither U nor Th were detected with a gamma ray spectrometer capable of resolving these elements. As determined with a Geiger counter, radioactivity is within the range of background counts along the entire outcrop.

5. *Minerals Observed and Relative Amounts:*

A. ECONOMIC

Major:	
Minor:	Galena
Trace:	Sphalerite (orange to black)

B. GANGUE

Major: Quartz (detrital), carbonate-apatite* (The few largest pieces have a cellular, bone texture.)

Minor: Microcline (?, detrital), muscovite var. sericite (authigenic)

Trace: Pyrite in apatite

6. *Paragenesis:* The galena is disseminated in the sandstone, interstitial to the sand grains.

7. *Geologic Description:* This occurrence is located on the southeast edge of the Allegheny Plateaus, adjacent to the Valley and Ridge Province. As such, it is just northwest of the Appalachian structural front. Sedimentary rocks near this occurrence have a monoclinal northwest dip beneath the plateau. There is no known structural element or deformation to which the mineralization can be directly related. The galena-bearing bed has a rather constant attitude of N30E, 31NW.

Jointing is very poorly developed, but when present is sometimes accentuated by thin films of secondary calcite. The calcite is probably forming at the present time by leaching and remobilization as a result of weathering. The sedimentary rocks themselves, however, are not calcareous, and wind-borne lime dust from quarries to the south is a possible source.

The galena-bearing bed varies from ½ to 2 inches (1.2 to 6 cm) in thickness and contains a pinkish to dark-gray sandstone lamina, rippled on the top but not on the bottom, sandwiched between gray to brownish-gray shales. The shale ½ inch (1 cm) above and below the sandstone contains brachiopods. Approximately 2 feet (0.6 m) above the sandstone, the shale contains fist-sized, tough, fine-grained siltstone loadcast nodules. Way (personal commun., 1974) describes the 10-meter-thick sequence which includes the mineralized sandstone as a shale with a few, thin siltstones, especially near the top. Mineralization occurs at the base of a fine-grained sandstone bed which itself is near the top of the 10 meter interval. Coarser grained interbeds are medium gray (N5) and the shale ranges from dark green gray (5GY4/1) to brown gray (5YR4/1). Marine fossils are present throughout the interbedded sequence, as well as at the base of the mineralized unit, less than 0.5 inch (1 cm) below the sulfides.

Located 132 feet (40 m) uphill along the road from the galena-bearing bed, there is a bed containing phosphatic material, probably apatite. This bed, 40 feet (12 m) stratigraphically above the sulfides, consists of a chloritic sandstone with brachiopods, millimeter-size phosphatic fossil fragments, and well-rounded quartz grains. Traces of apatite (verified by X-ray diffraction) also occur about 90 feet (28 m) stratigraphically below the sulfide-bearing bed in a burrowed siltstone.

Galena occurs on the east side of the road both 3 feet (1 m) above road level and 35 ± 5 feet (11 ± 2 m) along the same beds near the top of the cut.

Galena in trace amounts occurs in a similar bed at the same stratigraphic level on the west side of the road. The galena-bearing lamina is discontinuous, even on the east side, but reappears with similar characteristics at the same apparent stratigraphic horizon.

The origin of the lead and zinc is unknown, but may have been released from apatite[1] and shale during the Appalachian Orogeny and migrated over short distances into the more permeable, thin sandstone bed with possible local reduced areas. The galena appears to have either filled voids around sand grains or replaced the inter-grain matrix. The presence of robust brachiopods, crinoids, etc. immediately above and below the sandstone lamina suggests that the occurrence is not related to an euxinic environment. This occurrence is of no direct economic significance.

This occurrence was found by John H. Way of the Pennsylvania Geological Survey.

1. Carter (1969, p. 11) reported 0.15 to 0.20% Zn in rock samples from a phosphate-rich area in Juniata County.

37. MILLVIEW QUARRY, SULLIVAN COUNTY

(Trace Zinc-Lead-Arsenic Occurrence)

1. *Name:* Millview Quarry, reported to be owned by the Locke Estate.

2. *Location:* A. This small quarry is located on the east side of Mill Creek, about 1000 feet (300 m) northwest of the junction with Lick Creek, 0.9 mile (1.45 km) north-northeast of Millview, and 0.7 mile (1.1 km) north of Loyalsock Creek, Forks Township, Sullivan County. The quarry trends parallel to Mill Creek, here about N10E.

B. LATITUDE N: 41° 31′ 08″ LONGITUDE W: 76° 35′ 13″

C. TOPOGRAPHIC MAP: Overton $7\frac{1}{2}$-minute quadrangle.

3. *Host Rock:* Catskill Formation of Upper Devonian age. As described by Platt (1880a), the section observed in the quarry is, from top to bottom:

	Ft.	In.	Cm.
Red-brown sandstone	8	0	242
Coquina limestone	2	6	76
Slate	2	6	76
Limestone	3	0	91

A 2-foot- (61 cm) thick blue limestone layer, described by Platt as occurring above the red-brown sandstone, is not observable at present. The sulfides occur in the coquina limestone. This bed contains fossil brachiopods, bryozoans and crinoids. It also contains sparse, coal-like, pieces of "charcoal" up to several inches in length within the limestone. This bed is in places capped by "limonite" and gypsum, suggesting that weathering of pyrite has occurred. The red-brown sandstone overlying the mineralized bed contains crude plant fossils.

4. *Estimated Total Amounts of Ore Metals:*
   <1 g: Cu
   1-1000 g: Pb, Zn, As
   1-1000 kg:
   >1000 kg:

5. *Minerals Observed and Relative Amounts:*

A. ECONOMIC

Major:	
Minor:	Galena, sphalerite (red-orange to yellow to colorless), cerussite(?)
Trace:	Chalcopyrite

B. GANGUE

Major:	Calcite, pyrite (some replacing "charcoal")
Minor:	
Trace:	Arsenopyrite* (small, white metallic prisms near sphalerite), goethite as "limonite," gypsum

6. *Paragenesis:* Sphalerite and galena occur both replacing fossils and in younger, cross-cutting calcite veinlets.

7. *Geologic Description:* This limestone quarry was developed on the south limb of a gentle anticline which trends approximately east-west. Bedding in the quarry strikes N80E and dips 7S. No faults were observed in the quarry or in the exposures along Mill Creek as far north as the crest of the anticline. The galena and sphalerite occur as 1- to 3-mm-sized disseminated grains in a coquinoid limestone bed and as a few rich blebs in centimeter-wide calcite veinlets. The richest veinlets occur along a pronounced joint set which trends N2E, 90°, cutting this same bed. Most of the disseminated sphalerite and galena appear to be concentrated near the top of the coquinite bed. The radioactive background in the quarry and immediate vicinity is normal.

The carbon-bearing marine limestone seems to have served as a local reducing environment beneath the non-marine oxidized red-brown sandstone. The occurrence is of little economic importance for zinc, lead or limestone. Its exact relation to copper-uranium occurrences in the Catskill Formation is unknown. Platt (1880b, p. 92) noted that ". . . the large limestone deposit on the Loyalsock creek in Sullivan county, above Forksville, showed numerous thin streaks of galenite, enough when patiently extracted, to have yielded the small amount of lead needed by the tribes of that region," or (p. 80) ". . . the limited wants of savages." Platt (p. 92) felt that galena veins a few inches wide were likely ". . . known to the Indian tribes, the location being jealously guarded from the knowledge of white settlers. . . ."

PENNSYLVANIAN OCCURRENCE

38. SUGAR HILL QUARRY, JEFFERSON COUNTY

(Zinc Occurrence With No Known Potential)

1. *Name:* Sugar Hill Quarry owned by the Sugar Hill Limestone Company.

2. *Location:* A. This abandoned limestone quarry is located 3.7 miles (5.9 km) west of Brockway, 1.45 miles (2.3 km) northwest of Beechton, and 0.4 mile (0.65 km) north of Pa. Route 28. The quarry trends approximately north-south near the entrance and about N50E at its northeast end. The quarry, located in Snyder Township, Jefferson County, is about 60 feet (18 m) wide and 35 feet (11 m) deep.

B. LATITUDE N: 41° 15′ 02″ LONGITUDE W: 78° 52′ 08″

C. TOPOGRAPHIC MAP: The entrance to the quarry is in the Falls Creek 7½-minute topographic quadrangle, but the best exposures are in the Carman 7½-minute topographic quadrangle.

3. *Host Rock:* The zinc-bearing siderite nodules occur in very fissile, gray shale 0-5 feet (0-1.5 m) above the Vanport limestone Member of the "Clarion Formation." The Clarion Formation, part of the Pennsylvanian Allegheny Group, has been redefined as the Clearfield Creek Formation by Edmunds (1969). In an idealized "complete" sequence of the Clearfield Creek Formation, the Vanport marine limestone would occur between the obviously non-marine Upper Clarion (Scrubgrass or Clarion No. 3) coal (below) and the Lower Kittanning number one coal (above). However, in the Sugar Hill quarry proper these coals are not observable and perhaps not present. In the Sugar Hill quarry, the Vanport limestone is a gray to tan micrite which contains marine fossils. These are especially abundant in the top 4 ± 1 inches (10 ± 3 cm) of the Vanport where corals and large crinoids are common in a hard sideritic layer. This siderite-rich layer, classically referred to as the "Buhrstone iron ore bed," weathers to a reddish color, but is buff to gray when fresh. The fossils it contains are composed of white crystalline calcite.

4. *Estimated Total Amounts of Ore Metals* (exposed in quarry walls):
   $<$1 g:
   1-1000 g: Cu, Ba
   1-1000 kg: Zn
   $>$1000 kg:

5. *Minerals Observed and Relative Amounts:*
   ECONOMIC
   Major: Sphalerite (orange-brown)
   Minor: Chalcopyrite (tetrahedrons)
   Trace: Wurtzite (only rarely in dark-brown hexagonal prisms)

B. GANGUE

Major:	Siderite (both as a bed and as nodules), calcite (white only)
Minor:	Pyrite, barite (colorless cleavages)
Trace:	Gypsum

6. *Paragenesis:* Deposition of Vanport marine limestone terminated by bedded siderite; deposition of overlying marine shale with siderite nodules and development of cracks; wurtzite; chalcopyrite; sphalerite; pyrite; calcite and barite; secondary (supergene) gypsum. The relative time of chalcopyrite formation within the sequence of deposition is particularly uncertain.

7. *Geologic Description:* The Sugar Hill sphalerite and wurtzite location was found in 1973 by Viktoras Skema of the Pennsylvania Geological Survey. Within and surrounding the Sugar Hill quarry, bedding is horizontal. Although a few slickensides (including a few with pyrite films) can be observed within the Vanport limestone, there is no evidence of significant faulting, pronounced joints, or crosscutting veins. The richest nodules occur within about one foot (30 cm) of the top of the Vanport, but sphalerite can be found in nodules up to 5 feet (1.5 m) above the Vanport. Higher than this, nodules become scarce, larger, coarser grained (sandy), and barren of sulfides.

Even within a given stratigraphic level, the distribution of nodules is not homogeneous within the Sugar Hill quarry. For example, nodules are much more common along the west wall of the quarry than at the north end. The nodular zone, however, may extend far beyond the limits of the quarry.

Almost all nodules are oblate with their long axis parallel to bedding. The size of zinc-bearing nodules ranges from 2 inches (5 cm) to 1 foot × 6 inches (30 × 15 cm). Nodules smaller than this were found to be hard solid siderite without shrinkage cracks or zinc minerals. Many nodules contain calcite-filled shrinkage cracks which widen toward the center of the nodule, but never penetrate the outer rim. A few of the nodules contain marine fossils, indicating that the nodules formed in marine sediments. Some nodules consist of a core and rim of siderite separated by coarse white cleavable calcite or barite with accessory zinc sulfides. This and the fact that mineral-filled cracks never seem to penetrate the rim, suggest that zinc was present in the nodules prior to their final growth. Thus the available evidence suggests that such nodules were formed on the sea floor during deposition of the sediments or at the latest, during lithification and diagenesis.

The Vanport limestone is 5 feet 10 inches (1.8 m) thick in the Sugar Hill quarry. In the northeast end of the quarry, the Vanport is composed of 8- to 12-inch- (20 to 30 cm) thick beds, whereas toward the quarry entrance it is non-bedded and contains fossil rubble. At Sugar Hill, the Vanport is not noticeably cherty. Neither zinc nor copper minerals were observed in the Vanport proper.

The Vanport limestone is generally unknown in outcrop farther to the east. It appears to be replaced by the non-marine "Kittanning sandstone" of the "Clarion Formation" (Albert D. Glover, personal commun., 1974). The Vanport limestone at Sugar Hill is probably an eastern continuation of wedge B of Bergenback (1964). Unlike the other wedges, B was formed of chemical rather than detrital components. For example, the amount of pyrite (a non-detrital mineral) is higher in wedge B than in the others. According to Bergenback (1964), first a flint clay and then a cherty limestone would be encountered westward from Sugar Hill across the B wedge. Farther west, lay a narrow shallow arm off the main body of the sea which lay still farther to the west or southwest.

Seaman and Hamilton (1950) and Frondel and Palache (1950) first described the occurrence of wurtzite in siderite nodules from western Pennsylvania. Their occurrences have the following features in common with the Sugar Hill occurrence: 1) Pennsylvanian host rock, 2) the occurrence of zinc as sphalerite and wurtzite in siderite nodules generally occurring about one foot (30 cm) above a limestone (as the Brush Creek or Pine Creek limestones), 3) the paragenesis is generally from wurtzite to sphalerite to barite or calcite, 4) most occurrences are in undeformed rocks and 5) some nodules have a core-rim structure with zinc sulfides along the interface. These common features suggest that despite the greater abundance of zinc at Sugar Hill than at other similar occurrences in Pennsylvania, this occurrence belongs to the same genetic class of syngenetic or diagenetic deposits. As such, it has no known direct economic significance. Associated coals might have enhanced heavy metal contents.

TRIASSIC (NO DIABASE) OCCURRENCES

39. CHARLESTOWN AND BUCKWALTER MINES, CHESTER COUNTY

(Abandoned Mines With Possible Very Small Production)

1. *Name:* The Charlestown mine is owned by George (Dusty) Rhoads of the Bell and Clapper estate, Phoenixville.

2. *Location:* A. The Charlestown mine is located 1.25 miles (2.0 km) northeast of Charlestown, 1.55 miles (2.5 km) southwest of the intersection of Pennsylvania routes 23 and 29, and 0.45 mile (0.75 km) northwest of the ConRail (Penn Central) railroad bridge over Pickering Creek. The open verticle shaft is estimated to be 150 feet (45 m) southwest of the railroad line, 1200 feet (370 m) north-northwest of the Bell and Clapper main house, and at an elevation of about 195 feet (59.4 m). The mouth of the adit was not found. This area is in Charlestown Township, Chester County. See section 7, Geology, for data on the Buckwalter mine.

	Charlestown Mine	Buckwalter Mine
B. LATITUDE N:	40° 06′ 29″	Unlocated
LONGITUDE W:	75° 32′ 03″	

C. TOPOGRAPHIC MAP: The mine area is within the Malvern 7½-minute quadrangle.

3. *Host Rock:* The map of Bascom and Stose (1938) indicates that the host rock is Pickering gneiss which they describe as a metasedimentary graphitic gneiss with a major amount of quartz and minor amounts of potassium feldspars, biotite, and hornblende. The rock in the shaft walls is thoroughly weathered, but appears to have been a well-foliated quartz-biotite gneiss. The features of the Pickering gneiss, as emphasized by Bascom and Stose (1938), were the presence of formerly economic amounts of graphite and limonite, the latter believed to result from considerable pyrite and pyrrhotite.

4. *Estimated Total Amounts of Ore Metals:*

   $<$1 g:
   1-1000 g: Zn, Cu
   1-1000 kg: Pb
   $>$1000 kg: Ba

This estimate is a compromise between Turnbull's (1854, p. 323) report of ". . . but a few tons of ore" and the author's difficulty in collecting 25 g of sphalerite and 5 g of galena.

5. *Minerals Observed and Relative Amounts:*

A. ECONOMIC

Major:	Pyromorphite, anglesite
Minor:	Sphalerite (golden-brown), galena, cerussite
Trace:	Chalcopyrite, malachite, linarite(?)

B. GANGUE

Major:	Quartz, barite, limonite
Minor:	Hematite
Trace:	

6. *Paragenesis:* Generally unknown, but some galena occurs completely within the tips of small clear euhedral quartz crystals.

7. *Geologic Description:* The Charlestown mine is located in Pickering gneiss about 100 feet (30 m) south of the Triassic basin (Bascom and Stose, 1938). The same authors show another zinc mine, the Buckwalter, 0.53 mile (0.85 km) S84W of the Charlestown mine. The Buckwalter mine should be located on Fairview Farm, but could not be found by the author, nor by Raymond Lauer (the present caretaker), nor by William Buckwalter (the former owner whose family has held the land since 1720) nor by A. V. Heyl and G. N. Bozion. The location given by Bascom and Stose for the Buckwalter mine places it on the eastern, upthrown side of a small, NE-trending fault. Rogers (1858, p. 676) notes that it was on the west bank of a ravine.

Rogers' (1858) map shows the Charlestown vein as having a length of 0.85 mile (1.35 km) and trending N37E. The Buckwalter vein was shown to have a possible length of 0.55 mile (0.90 km) and a trend of N54E.

Rogers' (1858) map indicates a trap dike between the Charlestown and Buckwalter veins and he notes (p. 702):

> They traverse equally the oldest strata of the region, the gneiss, and the ancient paleozoic limestone of the Chester County Valley, and the newest formation in the district, the Middle Secondary or Red shale and sandstone. It is manifest that some at least of these igneous injections are of a date subsequent to the deposition of the red sandstone, and it is highly probable that even many of those included within this tract of the oldest rocks are of the same relatively recent age . . . .

Bascom and Stose (1938) show the E-W-trending dike 0.25 mile (0.35 km) west of the Charlestown mine as Precambrian gabbro or diabase. In the text (p. 42), they distinguish Precambrian from Triassic dikes. The author has found only meta-diabase with titanaugite and rather high TiO_2 contents in the Phoenixville district (Smith, 1973, p. 50-54). These are quite distinct from the three types of diabase known to occur in the Triassic basin. Because of nearly identical mineralization at Audubon and New Galena, it is known, however, that the mineralization of the Phoenixville district is Triassic or younger. Trace-element data on sphalerites and galenas from the Phoenixville, Ecton and New Galena districts will be needed to help distinguish between remobilization of metals in the host rock; gneiss, silt-sandstone and black shale, respectively; or hydrothermal solutions from large diabase plutons.

Turnbull (1854, p. 323) reports that the Charlestown mine shaft was 180 feet (55 m) deep and the vein ". . . apt to be filled up in many places with

inferior deposit, containing very little true lead ore." In 1854 the mine had ten employees, a 60 horsepower engine, a horse whim and capstan and an outhouse containing two giggin machines.

Rogers (1853) described the Charlestown mine as follows:

> This vein has been opened by a water-level or adit, south-westward from its northeastern end for a length of more than 800 feet, and is traceable much farther towards the south-west by its surface vein-stones or gossans which are stained with phosphate of lead. It is a regular lode, having quite well-defined bounding walls, though inasmuch as the present adit is nowhere at a greater depth beneath the soil than thirty-eight or forty-feet, and the whole vein is in a somewhat decomposed state, these walls are not everywhere as well marked as they will be farther down. It occurs in the gneiss, which it cuts somewhat transversely. This gneiss dips towards the south at angles from 45° to 60°, while the vein itself has a dip or underlie of 70° or more towards the southeast. The walls of the lode are chiefly granitic gneiss and granite, the feldspar of the granite being half decomposed. Its course is nearly straight, being about S. 32° W. with occasional local deflections. In thickness, it would seem materially to exceed the Wheatley Lode, being at least from two to two and a half feet wide, and in some places four feet and even more.
>
> Near the surface, the lode retains very little metallic ore, even in the shallow adit now alone opened in it, we meet only with some of the phosphate and carbonate of lead, with a little galena. Yet, notwithstanding this present poorness in metalliferous matter, so nearly identical are its vein-stones with those of the Wheatley vein, where there was a nearly equal destitution of metallic ores at the same shallow depth, that I hesitate not to pronounce it, from all its external and general indications, quite as promising a repository of lead. Possibly, the proportion of productive ore in the vein to unproductive mineral matter may exceed that in the other mine, yet it is fully one-half wider between its walls; and this fact, and the increased cheapness of mining thereby caused, will probably quite compensate any comparative difference in richness. Its greater width is very probably one cause of its gossans, showing less ore at a corresponding shallow level below the soil; for the decomposition of the mineral materials has from this cause manifestly penetrated to a greater relative depth.

At present, the surface opening is 40 feet (12 m) × 25 feet (8 m) and estimated to be 20 feet (6 m) deep. Metallic refuse, including autos, prevents use of a Brunton compass in the shaft. In the northeast wall of the shaft, the author estimated that foliation and pronounced joints trend northeast and measured that foliation dips 21SE and joints 80W. Because of creep and probable local variations, Rogers' measurements are preferable. His determinations indicate that the vein cuts both gneissic foliation

and jointing. The scarcity of ore minerals suggests that Rogers may have been overly optimistic because of the vein's width.

40. CHESTER COUNTY MINE, CHESTER COUNTY

(Abandoned Mines With Lead-Zinc Production)

1. *Name:* The Chester County mine is owned by Pickering Hunt Club and the Southwest Chester County mine, by the Thompson brothers.

2. *Location:* A. The Chester County mine is located 2000 feet (610 m) southwest of Williams Corner (intersection of Creek Road and White Horse Road), 875 feet (267 m) southeast of the intersection of Creek Road and Tinker Hill Road, and about 150 feet (46 m) south-southeast of the Pickering Hunt Club barn (Figure 82).

The Southwest Chester County mine (main shaft) is located 3000 feet (914 m) southwest of Williams Corner, 1250 feet (381 m) south-southeast of the intersection of Creek Road and Tinker Hill Road, and 1075 feet (328 m) southwest (S55W) of the Chester County mine. An air shaft to this is detectable as a mineralized dump 375 feet (115 m) S58W of the main Eastern Mining and Milling Company shaft, here called the Southwest Chester County mine. Both mines are in Charlestown Township, Chester County.

The Chester County mine proper is known to have had 8 shafts by 1852, and it is not known with certainty which of the shafts have been located

Figure 82. The Phoenixville lead-zinc-copper district as it appeared in the late 1850's (Rogers, 1858).

above. Similarly, the adit entrance along Pickering Creek has not been located.

	Chester County	Southwest Chester County
B. LATITUDE N:	40° 06′ 20″	40° 06′ 15″
LONGITUDE W:	75° 31′ 08″	75° 21′ 18″

C. TOPOGRAPHIC MAP: Malvern $7\frac{1}{2}$-minute quadrangle.

3. *Host Rock:* Bascom and Stose (1938, p. 124) describe the host rocks as Precambrian granodiorite and quartz monzonite. However, gneissic foliations are apparent and the general term "granitic gneisses" may be more appropriate. Genth (1851, p. 20-21) described the host as orthoclase biotite gneiss, hornblende replacing biotite to the southwest. The strike of the gneissic foliation was NW and the dip 40NE. The gneiss was cut by granitic veins (dikes?) trending NE.

4. *Estimated Total Amounts of Ore Metals:*

A. <1 g:

1-1000 g:

1-1000 kg: Ag

>1000 kg: Pb, Zn, Cu

B. ASSAYS: Reed (1949b) reports the shipment of 100 tons of galena concentrate which assayed 79% Pb and $7\frac{1}{2}$ oz Ag from Southwest Chester County mine in 1920. Genth (1851) reported in the First Directors Report that lead metal from the Chester County mine proper contained 57 oz Ag/ton, and that a chalcopyrite concentrate contained 6 oz Ag/ton. James C. Booth (in Genth, 1851) in the same report listed cerussite ore at 5 oz Ag/ton, and galenas ranging from 18 to 35 oz Ag/ton. Genth's "lead lode" coarse galena contained 16 oz Ag/ton and the fine radiating granular galena 12 oz. He found 71.5% Pb and 1.6 oz Ag in pure pyromorphite. Turnbull (1854, p. 53) reported the recovery of 25 to 37 oz Ag/ton of metallic lead. Turnbull may, however, have been overly zealous, as he also reported the production of ". . . about fifty to fifty-five tons of lead from every hundred pounds of rich ore. . . ."

5. *Minerals Observed and Relative Amounts:*

A. ECONOMIC

	Chester County	Southwest Chester County
Major:	Sphalerite (deep-golden-brown), pyromorphite,[1] galena (fine-grained and coarse cleavages), cerussite[1]	Sphalerite (golden-brown), galena (fine-grained and coarse cleavages)

1. Nearly all of the 1,014,929 pounds (507 tons or 459,000 kg) or ore concentrates smelted from Chester County mine ore in 1852 consisted of pyromorphite and cerussite (Sharwood, 1852, p. 4).

Minor:	Anglesite (crystals to 1 inch (2.5 cm)), chalcopyrite	Pyromorphite,[2] anglesite[2]
Trace:	Wulfenite (red-orange), brochantite, smithsonite, linarite, covellite (Genth, 1851, p. 22)	Wulfenite (red-orange ditetragonal pyramids), vanadinite, descloizite, smithsonite, cerussite[2]
B. GANGUE		
Major:	Quartz (with galena included in crystal tips)	Quartz (with galena included in crystal tips), ferroan dolomite
Minor:		
Trace:	Calcite, goethite (pseudomorphs after pyrite), hematite	Barite, calcite

6. *Paragenesis:* For both the Chester County mine proper and the Southwest Chester County mine: Fracturing of granitic gneiss; ferroan dolomite; cockscomb-quartz with galena beginning near the end of quartz deposition; galena; sphalerite; and barite. The age of the chalcopyrite is uncertain, but probably formed after the quartz and with the galena or earlier with the ferroan dolomite.

7. *Geologic Description:* The Chester County mine proper was active from 1850 to June 9, 1853, and the Southwest Chester County mine reactivated and extended from about 1918 to 1920. The "Sherwood" mine of Turnbull (1854, p. 53) is probably the Chester County mine based on its location between the Montgomery County and Wheatley mines and the fact that Dendy "Sharwood" (spelling verified from signatures) was superintendent of the Chester County mine. Because the Funk tract begins 39 perches (644 feet) south of Crisman (Chester County Mining Company) tract, the "fourth" or 90-foot- (27.4 m) deep Funk mine of Turnbull may be the precursor of the Southwest Chester County mine or one of the ill-defined diggings between the "proper" and Southwest Chester County mines, as for example, the wooded area about 250 feet (75 m) northeast of the Southwest Chester County mine.

The following, probably incomplete, production data are available:

Mine	Production	Period	Reference
Chester County	20 tons dressed galena	before June 1850	Sharwood, 1851, p. 6
do.	30 tons dressed galena	June 1850-Fall 1850	do., 1851, p. 10
do.	200 tons dressed galena	Fall 1850-May 1, 1851	do., 1851, p. 10

2. Substantially more abundant prior to removal by rockhounds.

do.	150 tons unknown ore	May 1, 1851-Nov. 1, 1851	do., 1851, p. 10
do.	443 tons dressed galena	Nov. 1, 1851-Nov. 1, 1852	do., 1852, p. 2-3
do.	507 tons pyromorphite plus cerussite	1852	do., 1852, p. 4
do.	About 1 ton every three weeks)?	Nov. 1, 1852-June 9, 1853	Turnbull, 1854, p. 53
Southwest Chester County	500 tons ore	1919	Reed, 1949b, p. 3
do.	100 tons galena concentrates[3]	1918-June 1, 1920	Miller, 1923, p. 10

This totals 1,243 tons of galena ore plus probable substantial oxidized ore. Based on examination of the dumps and Miller's statement that the 1850's operation ceased because of the abundance of sphalerite, it seems likely that an equal or substantially larger quantity of sphalerite could have been produced.

The Southwest Chester County mine in the Eastern Mining and Milling Company was entered by Miller (1923, p. 6) who described the vein as follows:

	Inches	*Centimeters*
Foot wall, prominently slickensided gneiss		
Thin streak of galena in shattered quartz	2	5
Barren impure quartz	1	3
Streak of sphalerite in quartz	1	3
Shattered quartz and decomposed rock with nests of white quartz and small bunches of galena	31	80
Streak of galena and quartz with some clay gouge	3 to 6	8 to 15
Open fissure, walls lined with quartz crystals with occasional crystals of galena	2	5
Hanging wall		

Miller noted that the hanging wall was also slickensided in places.

The 1917-1920 operation probably centered on the Southwest Chester County mine. This is suggested by the lack of shafts in this area on the 1851 report, the recent appearance of these excavations on the 1947 aerial photographs, and the presence of an intact head frame; open, cribbed shaft; and mill foundation just east of the shaft in 1930 (A. V. Heyl, personal commun., 1976). Old air photos also show a small distinct clearing

375 feet (114 m) S55W of the shaft indicated on Plate 6. This fits well with Reed's (1949b, p. 6) statement that "After the Chester County mine had been reopened in 1917, two shafts about 400 feet apart were connected by two levels at depths of 140 and 200 feet." Reed reports that 900 feet (275 m) of drifts, winzes, and raises were driven during this period.

The mine map accompanying the 1851 Chester County Mining Company report and the 1852 report cross section are included as Figure 83 and Plate 6 respectively, with additional information from Sharwood's and Genth's portions of these reports. The map of Reed (1949b) appears incorrect. The following essential data should be noted.

A. The copper lode was 22 to 30 inches (55 to 75 cm) wide, had a strike of N34E, and dipped to the southeast.

B. The lead lode, was 12 to 36 inches (30-90 cm) wide, had a strike of N53E and dipped 75NW.

C. By 1851, the adit was 1367 feet (417 m) long and extended about S34E from Pickering Creek to the Wheatley property. At that time there were approximately 1318 feet (402 m) of drifts on the adit level.

D. By 1852, the Engine Shaft was 120 feet (36 m) deep, but apparently never completed to the 300-foot (92 m) level where the lead and copper veins were projected to meet.

E. The southwest exposure of the lead lode on the adit level was described as ". . . not rich although it has made good ore in places, and is in kindly ground" (Sharwood, 1852, p. 2). On the ten fathom level, the ore was rich in galena, ". . . but not uniformly rich . . ." with some zinc blende, in a vein with quartz and gossan from 1 to 3 feet (30 to 90 cm) thick. On the twenty fathom level the ore consisted of galena, without the phosphates and carbonates present on the upper levels, in a $2\frac{1}{2}$-foot (76 cm) vein cutting county rock with a ". . . kindly appearance."

F. A disbase dike containing ". . . rounded boulders . . ." of chalcopyrite was stoped from the 10 and 20 fathom levels.

Miller (1923, p. 10) reports that by 1853 there were 1342 feet (409 m) of drifts on the 10-fathom (60 foot) level, 1130 feet (344 m) on the 20-fathom (120 foot) level, and 916 feet on the 30-fathom (180 foot) level. Thus, there are a minimum of 6073 feet (1851 m) of workings (excluding 9 shafts) in the Chester County mine complex above. As shown in Plate 6a, substantial lengths of 60-foot- (18 m) high open stopes extend nearly to the surface. The extent of underground workings and shaft locations should be considered before proceeding with any urban or suburban development at this location. Extensive core borings, on the order of 50-foot (15 m) centers to depths of 400 feet (120 m) over the entire area, would be advisable for safe engineering design and the development of special construction techniques.

3. Probably the concentrate from the 500 tons of ore listed immediately above.

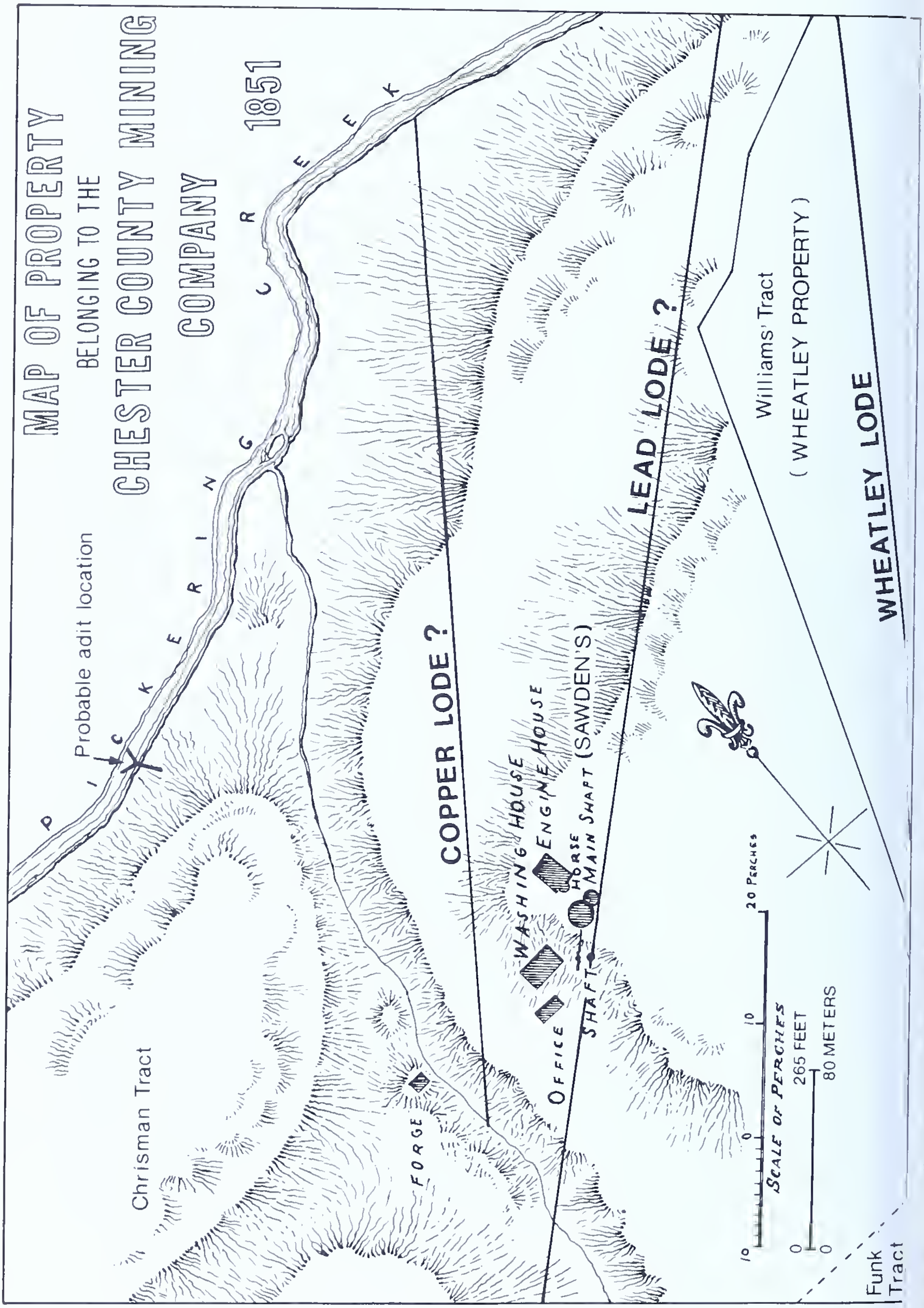


Figure 83. Chester County min

41. JUG HOLLOW MINE, CHESTER COUNTY

(Abandoned Zinc-Lead Prospect)

1. *Name:* The Jug Hollow mine is probably the Petherick's Penn Mining and Smelting Co. shaft of Rogers' map (1858, v. II, p. 674-675). Gordon (1922, p. 177) incorrectly equates Jug Hollow mine with the Napoleon mine. Gordon's location for Jug Hollow mine, as given by Kemp's system of ninths (Norristown 4752), is the same as Rogers' location for the Napoleon mine. Likewise, Gordon describes the host rock for his Jug Hollow mine as Triassic shale. However, as shown by Rogers' map, the Napoleon mine is a prospect distinct from Jug Hollow-Pethericks Penn.

2. *Location:* A. The mine and dumps are in Jug Hollow, 0.6 mile (1 km) southwest of Brittains corner, Schuylkill Township, Chester County. The mine is about 150 feet (46 m) southeast (uphill) of Jug Hollow Road at an elevation of about 340 feet (103 m). By road, it is 0.63 mile (1.0 km) southeast of the intersection of Jug Hollow Road with Valley Park Road. The vertical shaft is 435 ± 25 feet (130 ± 8 m) N34E of the Putschi house.

B. LATITUDE N: 40° 05′ 36″ LONGITUDE W: 75° 29′ 09″

C. TOPOGRAPHIC MAP: Valley Forge $7\frac{1}{2}$-minute quadrangle.

3. *Host Rock:* A gray-green chlorite(?) schist with common milky quartz veins. The schist is not distinguished on the 1:250,000 scale of the state geologic map (Gray and Shepps, 1960), but presumably would be of Precambrian or lower Paleozoic age. Miller (1923, p. 2) described the host rock as Baltimore gneiss.

4. *Estimated Total Amounts of Ore Metals:*[1]

A. <1 g:

1-1000 g: Cu, Pb

1-1000 kg: Ba, Zn (low end of range)

>1000 kg:

B. ASSAYS: A. V. Heyl, U. S. Geological Survey, reports a semi-quantitative emission spectrographic analysis of a grab sample of the best "ore" on the dump showing 0.07% Cd in a sample containing about 5% Zn. This analysis suggests that the sphalerite may be cadmium-rich.

5. *Minerals Observed and Relative Amounts:*[2]

A. ECONOMIC

Major:	
Minor:	Chalcopyrite, sphalerite (yellow-green to golden-brown)
Trace:	Galena, anglesite, malachite, "copper pitch" (tenorite?)

1. Based on examination of dumps which have been picked over by generations of mineral collectors.
2. The minerals credited by Gordon (1922, p. 177) to Jug Hollow mine should properly be credited to the Napoleon mine.

B. GANGUE[3]

Major:	Calcite (tan rhombohedral cleavages), ferroan dolomite, quartz (two varieties: a. clear, crystalline, and b. gray chert), barite
Minor:	Chlorite or muscovite(?)
Trace:	Limonite

6. *Paragenesis* (from oldest to youngest): Quartz; chalcopyrite; barite; sphalerite; quartz; galena; anglesite and malachite. There is some overlap between quartz, barite and sphalerite.

7. *Geologic Description:* At the surface, the vertical shaft is 35 × 35 feet (11 × 11 m). The sides are steep and the shaft is filled to within about 15 feet (5 m) of the surface with trash. The mineralized part of the dump is north-northwest of the shaft. When visited by C. N. Bozion and A. V. Heyl (personal commun., 1976) in 1967, a one-foot- (30 cm) wide vein was partly exposed in the shaft walls and trended about N20E.

3. A. V. Heyl (personal commun., 1976) observed an early generation of blue quartz veins in the schist. These are cut by the lean sphalerite-bearing veins.

42. MONTGOMERY COUNTY MINE, CHESTER COUNTY

(Abandoned Lead-Zinc Mine With Small Lead Production)

1. *Name:* The Montgomery County Mine is reportedly owned by David Howe, James Brennan and other residents along Tinker Hill Road.

2. *Location:* A. The main shaft of the Montgomery County Mine is located in the front yard of the David Howe property, 45 feet (14 m) northwest of Tinker Hill Road and 95 feet (30 m) northeast of Graham Road, Schuylkill Township, Chester County. The mine area is at an elevation of about 190 feet (58 m) and is located 0.75 mile (1.2 km) southwest of Williams Corner, about 350 feet (110 m) northeast of the Charlestown Township line, and 0.6 mile (1 km) northeast of Pa. Route 29 over Pickering Creek. The adit entrance was not located.

B. LATITUDE N: 40° 06′ 18″ LONGITUDE W: 75° 31′ 32″

C. TOPOGRAPHIC MAP: Malvern $7\frac{1}{2}$-minute quadrangle.

3. *Host Rock:* The country rock is not observable because of well-manicured residential lawns over the mine area. Rogers (1858, p. 700) describes the host for this and adjacent veins as gneiss of three varieties: 1) thin-bedded micaceous gneiss, 2) ferruginous hornblende gneiss, and 3) thick-bedded quartz-feldspar granitic gneiss. Reed (1949b, p. 4) says the host is granodiorite. There is some Precambrian diabase float on the Howe property.

4. *Estimated Total Amounts of Ore Metals:*

A. <1 g:

1-1000 g:

1-1000 kg: Cu, Ag
>1000 kg: Zn, Pb (There were probably well over 10,000 kg of sphalerite)

B. ASSAYS: Miller (1924, p. 42), probably referring to the superintendent's report of May 31, 1853, notes that some galena from the Montgomery mine contained 15 to 18 oz of silver per ton.

5. *Minerals Observed and Relative Amounts:*

A. ECONOMIC

Major:	Sphalerite (honey-yellow to golden-brown), galena
Minor:	Pyromorphite
Trace:	Smithsonite, chalcopyrite, anglesite

B. GANGUE

Major:	Quartz (colorless, mm-sized crystals)
Minor:	Dolomite (ferroan, tan, coarse crystalline), hematite* (reddish fibrous)
Trace:	Marcasite(?), calcite, pyrite

6. *Paragenesis:* Faulting of gneissic country rock; quartz, chalcopyrite, and galena; sphalerite and pyrite; calcite; pyromorphite, anglesite, and smithsonite by supergene alteration. There is definite overlap of quartz and galena. The relative position of the dolomite is unknown.

7. *Geologic Description:* Miller (1924, p. 42) had access to a report of the mine superintendent, dated May 31, 1853, stating that there was one shaft 118 feet (36 m) deep, three other shallow shafts and an adit. Besides the main vein, four small, parallel veins, with widths varying from 3 to 16 inches, were cut by an adit.

Turnbull (1854, p. 53) described the operation as follows:

> This mine has only been in operation for about 12 months, and has sunk a shaft some 120 feet; the encouragement to progress has been very good, the ore is abundant; but they have been considerably annoyed with the large quantity of zinc ore, which has to be separated by washing; they had some 4 or 5 tons on hand. . . . They had some 15 miners at work, and one of them was complaining of the want of proper ventilation in the mine, so that their lamp or candle would not burn, and they had to come up after each blast to get rid of the smoke. . . .

In addition to the main shaft (S15E of the Howe house), there is presently a shallow pit about halfway between the Howe and Brennan houses. This probably represents one of the shallower shafts and is S15W of the Brennan house N24E of the Howe house, about 140 feet (43 m) northwest of Tinker Hill Road, and about 270 feet (83 m) northeast of Graham Road.

Based on the abundance of large, nearly pure sphalerite masses on the dumps, the vein probably had value as a small high-grade zinc mine prior to suburbanization. It is hoped that the present houses along the northwest side of Tinker Hill Road are not underlain by mine workings.

43. NEW GALENA, BUCKS COUNTY

(Former Lead-Zinc Producer With Possible Reserves)

1. *Name:* New Galena, or New Britain Lead Mine, or Dickeson Lead Mine, or Doan's Mine, or Pine Run Lead Mines presently owned by the Bucks County Park Commission.

2. *Location:* A. The three areas of exploration and development at New Galena are located in quadrants formed by the intersection of Old Limekiln Road and the North Branch of Neshaminy Creek (Figure 84). The following were observed in May 1972 just after bulldozing for a water-supply reservoir had begun: the NE quadrant contained three or four shafts and three small pits. The SE quadrant contained an Engine Shaft, a reported shaft to the Dickeson vein (this last not observed), and a large "Gauphin or longitudinal opening." The SW quadrant contained two shafts, one with an adjacent pit.

The shafts and pits are located on Figures 84 and 85, the latter from Ashmore (1863). The intersection of Old Limekiln Road and the North Branch Neshaminy Creek is 900 feet (275 m) southeast of New Galena (the former intersection of New Galena and Old Limekiln Roads) and 3.4 miles (5.4 km) northwest of Doylestown. All of the shafts and pits are in New Britain Township, Bucks County.

B.	LATITUDE N	LONGITUDE W
NE quadrant shaft cluster	40° 19′ 48″	75° 11′ 01″
SE quadrant gauphin	40° 19′ 44″	75° 11′ 08″
SW quadrant shafts	40° 19′ 39″	75° 11′ 12″
North Branch Neshaminy Creek-Old Limekiln Road intersection	40° 19′ 47″	75° 11′ 12″

C. TOPOGRAPHIC MAP: All of the shafts and pits are on the Doylestown 7½-minute quadrangle.

3. *Host Rock:* Willard and others (1959) mapped the area as gray to black argillite of the Triassic Lockatong Formation. They show the mineralized area as being 975 feet (300 m) above the top of the Stockton Formation. Mineralized samples of black argillite found on the dumps confirm Lockatong Formation as the host at depth. No Triassic diabase was found on any of the mine dumps. Rounded diabase boulders in the area appear to be float from the dike 0.2 mile (0.35 km) to the southeast. Diabase reported on the dumps in the SE quadrant by Earl (1950b) is probably float. P. E. Hotz described the U.S. Bureau of Mines drill core (intended to pass beneath the mines) as gray to black shale, and does not mention diabase (Earl, 1950b). The aeromagnetic map of Bromery and Griscom (1967) does not show any anomalies suggesting a significant amount of diabase in this area. Thus, the earlier reports of diabase appear to be incorrect.

4. *Estimated Total Amounts of Ore Metals:*

A. <1 g: Mo

1-1000 g: Au
1-1000 kg: Ag, U(?)
>1000 kg: Pb, Zn

B. ASSAYS: Dickeson (1860) reports an assay from the 38-foot shaft bearing his name of 15 oz Ag/ton in 85% lead ore.

Annear (1862) reports that Jacob and George Neimeyer shipped 106 tons of ore which yielded 75% Pb and 11 oz Ag/ton. As of 1862, an additional 80 tons was stockpiled. Ashmore (1863) reports a total production of 200 tons of 76% lead and $7^{1}/_{4}$ oz Ag/ton. Miller (1924) reported that "Some of the galena has yielded 10 to 15 ounces of silver and 10 cents in gold per ton." A. V. Heyl (personal commun., 1968) reports that the galena contains 300 ppm Ag (8.75 oz/ton), <.05 ppm Au, 1700 ppm U, 370 ppm V, and 37 ppm Sb. The uranium and vanadium contents are particularly interesting and suggest a genetic relation to the black shale.

Most of the observed ore (1972) was in the NE quadrant dumps which were not located by Talmage (1923), Miller (1924), or Earl (1950b). Thus, the reported production is probably quite low.

5. *Minerals Observed and Relative Amounts:*

A. ECONOMIC	NE quadrant	SE quadrant	SW quadrant
Major:	Sphalerite (lemon-yellow to golden-brown), galena	Sphalerite, galena	Sphalerite (brown), galena, cerussite*
Minor:	Sphalerite (dark-brown to black, early)	Malachite, chalcopyrite, cerussite	Chalcopyrite (in galena), anglesite,* linarite, brochantite,* malachite, chrysocolla*
Trace:	Chalcopyrite	Pyromorphite, linarite, brochantite(?), anglesite, covellite*	Pyromorphite,* wulfenite, posnjakite*
B. GANGUE			
Major:	Dolomite,* dolomite (ferroan)	Quartz	Quartz
Minor:	Quartz	Pyrite	Pyrite (cubic)
Trace:	Calcite, pyrite		

Previously reported minerals such as ankerite, barite, bornite, fluorite, greenockite, hemimorphite, siderite, smithsonite, and tenorite were not observed during the present study.

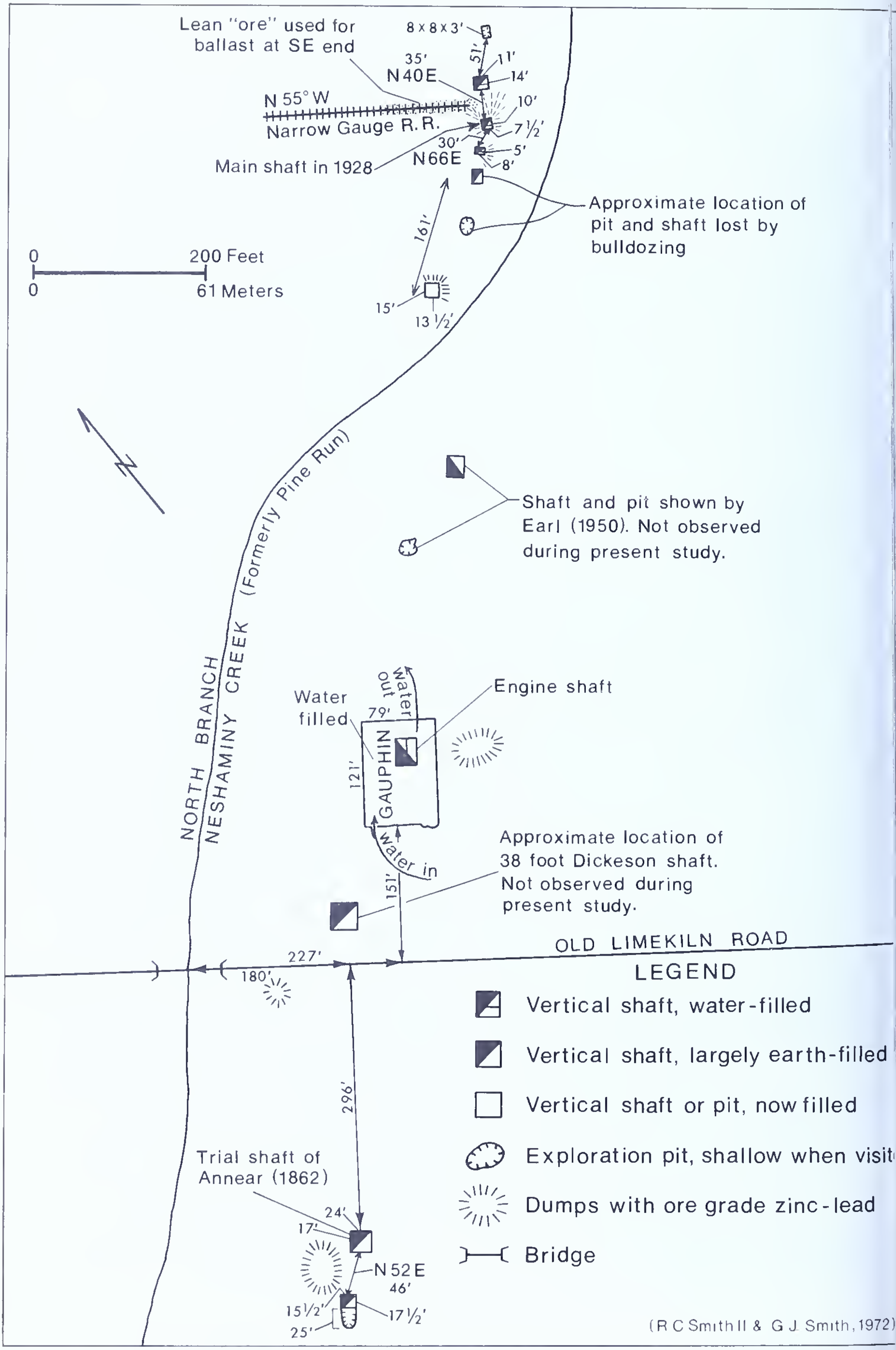


Figure 84. Zinc-lead workings at New Galena mine, Bucks Co.

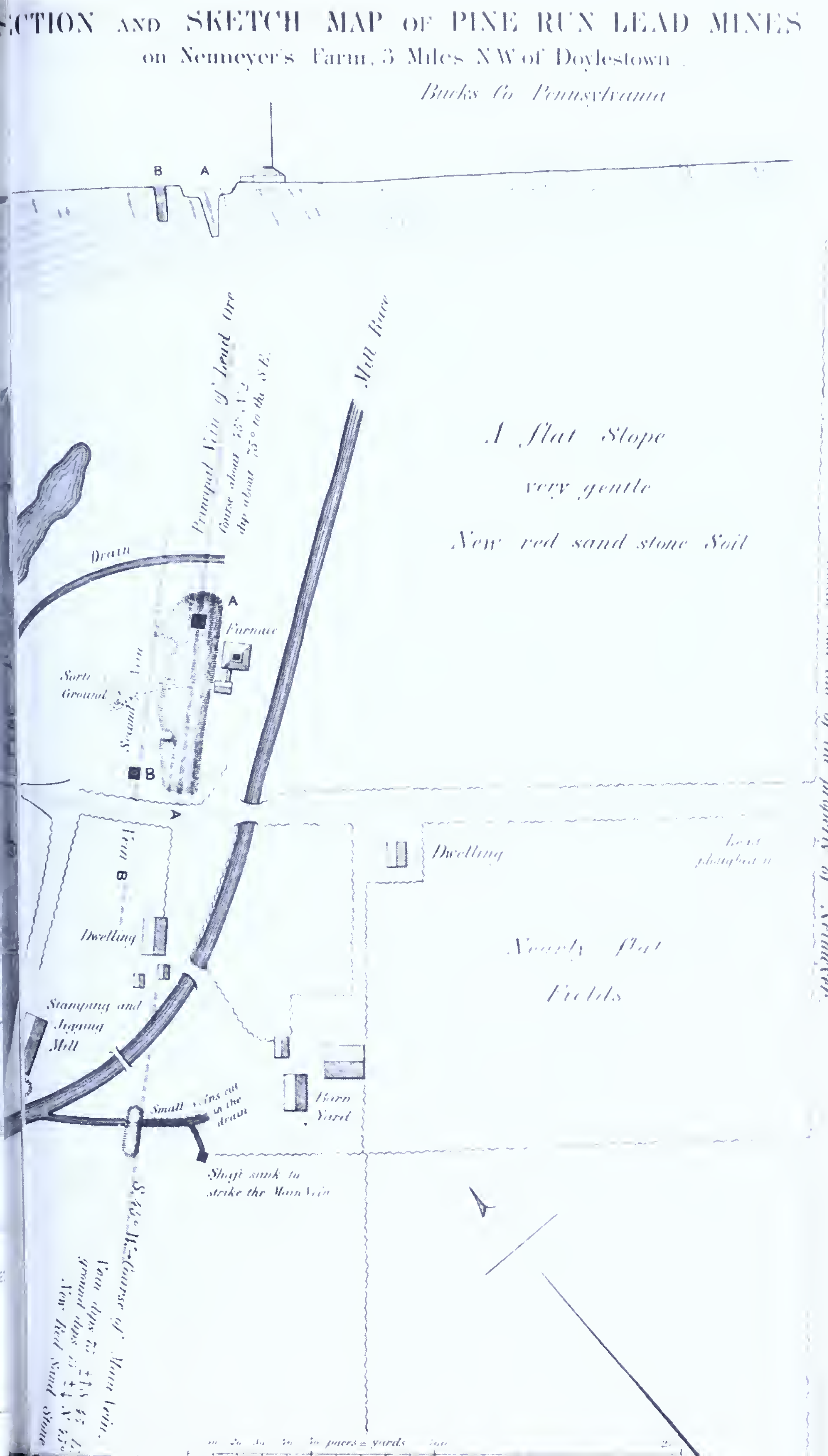


Figure 85. New Galena property from Ashmore (1863), (courtesy of A. V. Heyl, U.S. Geological Survey).

6. *Paragenesis:* For the NE quadrant: Lockatong deposition with syngenetic pyrite, ferroan dolomite, dark sphalerite and fine-grained galena; deformation; pyrite, lemon-yellow to golden sphalerite, galena and crystalline quartz; chalcopyrite? and lemon-yellow sphalerite; cubic pyrite; and calcite. In some cases, sphalerite from the NE quadrant appears to be replacing vein dolomite.

7. *Geologic Description:* New Galena is located within monoclinally-dipping Triassic black and gray argillite in an area where the dip is 12 ± 2° to the NW and strike is about N50E (Willard and others, 1959). The map of Ashmore (1863) shows a dip of 15° ± in a direction of N45W. The drill core data in Earl (1950b), however, yields dips of 25° to 40°. This may indicate that the drill holes were 15° to 30° steeper than planned. Willard and others (1959) indicate the presence of an approximately located NE-trending fault (Fountainville-Carversville fault) approximately 675 feet (175 m) southeast of the mineralization in the SE and SW quadrants. Based on the offset of the Lockatong-Stockton Formation contact, the southeast side of this fault has been dropped. This fault, as well as the Furlong fault 5 miles (8 km) to the southeast, have traditionally been assumed to be normal, steeply south dipping. Faill (1973) considers the possibility that they may be high-angle steeply northwest dipping reverse faults. It seems likely that the mineralization is above some form of fault which could have served as a channel for hydrothermal solutions.

Earl (1950b) states that the veins dip SE at 70°. This would yield an angle between the vein and bedding of about 85°, in agreement with small veins in argillite collected in the NE quadrant which intersect bedding at about 80°. Ashmore's (1863) map shows the veins dipping 75° to the southeast, but his text states that some are nearly vertical. He reports that veins cut bedding at right angles.

Breccia observed on the mine dumps in the NE quadrant suggest the presence of an unmapped vein-fault trending N45E. This unmapped fault would probably intersect the N60E Fountainville-Carversville fault of Willard and others (1959) in the SE quadrant, site of the large gauphin.

Cross sections in Plate 2 of Willard and others (1959) suggest that basement, possibly including favorable Beekmantown Group carbonate rocks, would be present beneath New Galena at a depth of about 6000 feet (1800 m). This is too deep for present recovery, but would be a convenient alternate source for the base metals at New Galena. Examination of the Beekmantown exposed northeast and southwest of Lahaska, ten miles (16 km) into the Triassic basin, is probably warranted.

The controls on ore deposition at New Galena appear to have been the occurrence of permeable breccia with replaceable dolomite in a reduced pyritic host probably containing minor acid-soluble carbonate (Smith, 1973, p. 178).

The New Galena mineralized area is over 1350 feet (410 m) long, but according to Earl (1950b), is shallow. The basis for Earl's conclusion, however, is poorly-controlled drilling. The vein is zoned horizontally and perhaps, vertically. Lateral zonation is demonstrated by Cu which was common in the SW and SE quadrants, but rare in the NE. For the NE quadrant, Corbin (1926) reports that chalcopyrite was rare, but present near the bottom of the 167-foot (50.8 m) shaft and absent near the surface. Corbin (1926) also noted an increase in calcite (ferroan dolomite?) and host rock bleaching with depth. The former, however, might have merely been leached from the near-surface portions of the vein. Vertical zonation may be shown by sphalerite. In referring to a vein examined by a 38-foot (12 m) shaft, Dickeson (1860) wrote:

> From the commencement of the sinking in the shaft, the lode gave a slight admixture of Sulphuret of zinc or "Blackjack." At the depth of about twenty feet from the surface it almost wholly disappeared, and at the extreme depth of the shaft, the evidence of its existence were so minute, as to afford the assurance, that no difficulty is to be apprehended from this positive enemy to perfect mineral formations.

M. H. N. (1928) reports the opposite, vertical zoning, i.e., increase of zinc relative to lead with depth.

The following information is available on workings and veins:

From Dickeson (1860)

The Dickeson shaft was 5 × 8 feet (1.5 × 2.4 m) in cross section, 38 feet (12 m) deep, and essentially vertical as was the 3- to 18-inch- (8-38 cm) wide galena vein. Fifty feet in an unknown direction from the Dickeson shaft, the same vein was found to be 12 inches (30 cm) wide in a 6-foot- (1.8 m) deep pit. A second lode (the main one?), parallel to that in the Dickeson shaft but 30 feet (9 m) to the southeast, was found to be 7 feet (2.2 m) wide with 4 feet (1.2 m) of galena as exposed in a 15-foot- (4.6 m) deep shaft. These are all in the SE quadrant.

From Annear (1862)

A large gauphin or longitudinal opening extending 256 feet (78 m) northeast from Old Limekiln Road was 20 to 44 feet (6 to 13 m) deep.[1] Except for alluvium filling in the southwest end, this checks with tape measurements by the author and his wife (Figure 84). The vein exposed in the gauphin averaged 2 feet (6 m) in width and contained galena, sphalerite and copper oxides [?]. A crosscut was driven in an unspecified direction (northwest) to intercept the Dickeson vein. About 53 feet (16 m) northwest of an engine shaft, the gauphin was 44 feet (13 m) for a length of 70 feet (22 m) and exposed a 3 feet (0.9 m) wide galena vein. The engine

1. A. V. Heyl (personal commun., 1976) notes that ore he observed on these dumps was cementing a tectonic breccia, rich in quartz, ferroan dolomite, and black-shale fragments.

shaft was sunk 20 feet (6 m) east (SE?) of the main load to intersect it at depth. This indicates that the vein dipped SE. The engine shaft intersected a 4-inch (10 cm) galena "Dropper vein."

"At a distance of 453 feet SW of the main working (Gauphin), a trial shaft has been sunk on the Lode, where it is two feet wide, of rich ore."

Ashmore (1863)

> There are two other veins, one on each side of the principal vein. A shaft has also been sunk 27 feet deep on another vein (Second or Dickeson), running parallel with the principal one, and on its northwestern side, and at a distance of 20 yards from it. At the surface this vein was no thicker than a knife blade, and at the bottom 18 inches thick. . . . In the drain cut across the measures south-east from the smaller opening, a great number of little veins were discovered in the smaller cross seams of the rock. Lead was ploughed up in the corner of the field near the south-east boundary of the farm, and at the creek bridge, and in other places. . . .

Lyman (1895, p. 2631)

> When visited in 1889, the mine was a hole some fifty yards long by twenty yards wide, full of water and quite inaccessible.

M. H. N. (1928)

The main shaft (in 1928, NE quadrant) was 8 × 12 feet (2.4 × 3.6 m) in cross section and 167 feet (50.8 m) deep. It is vertical for about the first 20 feet (6 m), but then dips 50° to 60° to the bottom.

> The dip of the Shale is possibly 15° (not measured), and the vein crossed it at a rather obtruse angle. [To the author this implies that Earl (1950b) is correct about the southeast dip of the vein, but that his bedding dips are 15 to 30° too steep.] The shaft followed a streak of high grade from practically the surface to its bottom, the vein itself having an average width of three or four feet, or thereabout. The thickest high grade spot was found at some point between forty and seventy feet from the surface. At this thickest place the maximum descriptions indicate two feet of galena and eight inches to a foot of blende, the two minerals being rather segregated and lying side by side. This was the widest spot of the high grade streak in the shaft. At two or possibly three places below this thickest point, the pay streak spread out to a thickness of possibly two feet.

One miner interviewed "was mildly of the opinion that the proportions of zinc to lead was greater in the lower part of the shaft than in the upper." A recent (approximately 1928) shaft 30 to 40 feet (9 to 12 m) north of the main shaft encountered 13 inches (33 cm) of zinc and lead to its total depth of 25 feet (7.5 m).

Earl (1950b)

In the SW quadrant, five pits along a trend of about N50E are shown in Earl's Figure 2. These range from 225 to 525 feet (58 to 160 m) southwest of

Old Limekiln Road. The smaller ones were apparently obliterated by bulldozing prior to the present author's examination. In the SE quadrant, a pit is shown about 470 feet (142 m) northeast of Old Limekiln Road and a shaft about 560 feet (170 m) northeast of Old Limekiln Road. These were not observed by the author, but have been approximately located on Figure 84 of this report.

As perhaps implied by Gault (Willard and others, 1959), the U. S. Bureau of Mines drill holes may not have extended far enough into the footwall side of the mineralized zone.[2] Earl (1950b) assumed that the vein trended N50E, whereas the present author obtained a trend of N45±2E and the recently obtained map of Ashmore (1863) shows the same N45E vein course. When a vein strike of N45E is plotted on Figure 2 of Earl (1950b), it appears that diamond drill hole No. 1 was too short by about 50 feet (15 m) and diamond drill hole No. 2 by about 110 feet (34 m). If the anomalously steep drill core axis to bedding data given by Earl is the result of steeping of the core axis with depth, then the holes were shorter than the amounts indicated above. Diamond drill holes 1 and 2 were stopped at vertical depths of 150 and 155 feet (46 and 48 m), respectively, whereas a good vein was still present about 150 feet (46 m) beneath the surface in the main shaft (1928) just to the northeast. Gault (Willard and others, 1959, p. 217) noted that "It is unfortunate that the area northeast of the shafts on the north side of North Branch Neshaminy Creek was not tested by drilling, if for no other reason than to verify the apparent disappearance of the veins in depth suggested by holes 1 and 2."

An order of magnitude estimate of the amount of lead and zinc at New Galena has been made on the assumption that the veins have the equivalent thickness of 1 foot (30 cm) of pure sphalerite and galena, are 1350 feet (415 m) long and 150 feet (46 m) deep. These assumptions yield 2.0×10^5 ft^3 of ore which, if it consisted of equal amounts of sphalerite and galena, would have a weight of 3.5×10^4 tons and present (1976) value of 1.4×10^7 dollars for Zn, 7×10^6 dollars for Pb, and 2×10^6 dollars for U in galena(?), and 4×10^5 dollars for Ag. This yields an order of magnitude value of 20 million dollars, suggesting that small-scale, profitable mining might have been possible. Unfortunately, this mineralized area is now a public water supply reservoir, and the area cannot be prospected for more attractive breccia zones and replacement beds.

Recently, trace golden to dark-brown sphalerite and galena, in pink calcite veins cutting slickensided Lockatong Formation, has been collected from the Edison quarry, Doylestown Township (A. I. Clauser, personal commun., 1975).

2. A. V. Heyl (personal commun., 1976) notes that in 1949 he and Paul Herbert, chief geologist of Gold Fields American, concluded that the U. S. B. M. erred in their drilling and evaluation.

44. PENNYPACKER MINE, CHESTER COUNTY

(Abandoned Lead Mine With Small Production)

1. *Name and owner:* The Pennypacker mine and adit are on John Thayer's estate near Harry Ott's estate.

2. *Location:* A. As shown by the map of Rogers (1858) (Figure 82), the Pennypacker mine and adit are located in Charlestown Township, Chester County, 1.5 miles (2.4 km) south-southwest of Williams Corner. The Pennypacker mine is the southernmost mine of the Phoenixville District. Based on mineralized float, the mine shaft was located 600 feet (185 m) southeast of White Horse Pike and based on topography, the adit mouth 700 feet (215 m) farther southeast. The mine was located at an elevation of about 405 feet (125 m), and the mouth of the adit at an elevation of about 350 feet (108 m). The adit entrance was roughly 100 feet (30 m) west of an unnamed creek which flows N35E in this area, and thence into Pickering Creek. The adit is about 20 feet (6 m) north of the Ott-Thayer property line and the mineralized float from the mine lies in a fence row just on the Thayer property and due north of the Ott estate barn.

	Pennypacker Mine	Mouth of Adit
B. LATITUDE N:	40° 05′ 17″	40° 05′ 13″
LONGITUDE W:	75° 31′ 10″	75° 31′ 03″

C. TOPOGRAPHIC MAP: Malvern 7½-minute quadrangle.

3. *Host Rock:* According to the geologic map of Bascom and Stose (1938), the area is underlain by granodiorite which they note includes areas of Pickering gneiss intimately intruded by gabbro and granodiorite. The dump for the adit, however, consists of decomposed granitic gneiss.

4. *Estimated Total Amounts of Ore Metals:*
   - <1 g: Cu[1]
   - 1-1000 g: Pb[1]
   - 1-1000 kg:
   - >1000 kg:

5. *Minerals Observed and Relative Amounts:*

A. ECONOMIC

Major:	
Minor:	
Trace:	Pyromorphite (green, zoned), galena, chalcopyrite

B. GANGUE

Major:	Quartz (clear, mm-size crystals)
Minor:	
Trace:	Goethite

6. *Paragenesis:* Hydrothermal quartz, galena, quartz, and chalcopyrite followed by supergene goethite and pyromorphite.

1. Probably at least a few kilograms were originally present.

7. *Geologic Description:* The Pennypacker mine and adit are located in an area with essentially no outcrop, and at present, no descriptions of the workings are available. Miller (1923, p. 11), for example, found "No definite information . . . regarding the . . . Pennypacker mine."

The adit trench is 35 feet (11 m) long and has an axis of N40W. The head (west) end of the adit trench has been filled in with fresh biotite gneiss, in an apparently successful attempt to seal the adit. The dump northeast of the adit is 35 feet (11 m) by 28 feet (8.5 m) by 3 feet (1 m) deep, yielding a volume of 3×10^3 feet^3 (85 m^3). This would permit a 150-foot-(46 m) long adit of 4×5 feet (1.2×1.5 m) cross section assuming that the dump now has a negligible porosity. A tree with a diameter of about 4 feet (1.2 m) at the base suggests that the dump is old. Based on Rogers (1858) map, the vein trended about N45E.

The Pennypacker mine is assumed to have been near the mineralized rock-pile fence between the Thayer and Ott estates. Some of the boulders in the fence are vuggy crystalline quartz up to 3 feet (1 m) in diameter. In the woods a few hundred feet southeast of White Horse Road, there is an underground reservoir for the Thayer estate. This may have utilized mineral exploration workings for water storage.

The vein-float is too weathered, leached and vuggy to evaluate its former economic significance. Trace native silver has recently been collected from the dumps of the Phoenix mine 0.7 mile (1.1 km) to the north-northwest, so assays of Pennypacker float for precious metals may be warranted.

45. PERKIOMEN-ECTON MINE AREA, MONTGOMERY COUNTY

(Abandoned Mines With Lead-Copper Production And Zinc)

1. *Name:* Perkiomen mine (one of several by this name in southeastern Pennsylvania) owned by the Lower Providence Rod and Gun Club, the Whim shaft of the Perkiomen mine reported to be owned by Charles Erskine, and the Ecton mine owned by the Audubon Wildlife Sanctuary. The Wetherill or "old" Perkiomen mine or the United Mine lode(?) (Miller, 1924, p. 36) is also owned by the Audubon Wildlife Sanctuary.

Based on property ownership study, A. V. Heyl (U. S. Geological Survey, personal commun., 1972) determined that the Wetherill mine is the original Perkiomen lead mine (distinct from the old Perkiomen copper mine near Schwenksville, Rose, 1970). Earl (1950c) notes that an 80-foot shaft and a 356-foot-long drainage tunnel were dug between 1808 and 1810 and assumes that this mining was done at the "Ecton mine, as a crosscut tunnel at creek level still exists west of the main shaft." This mining was done by "the Perkiomen Mining Company" (Miller, 1924). As measured during the present study by Smith, Varady, and Way, the 80-foot (24 m) level crosscut of

the Ecton mine is 285 ± 5 feet (87 ± 2 m) long (Figures 86-91), in agreement with D. Costanzo's (Audubon, Pennsylvania, personal commun., 1972) measurement of 290 feet (89 m). Because the distance from the site of the Wetherill mine to Perkiomen Creek is 350 ± 25 feet (108 ± 8 m), it is strongly suggested that Heyl is correct, i.e., the Wetherill mine is the old Perkiomen lead mine. Therefore, production and minerals prior to 1827 should be credited to the Wetherill-old Perkiomen mine. There does not appear to be any historic basis for locating the 1809 mining along Mine Run or stating that "The underground workings (of the district) are inaccessible . . ." (Miller, 1924, p. 21).

2. *Location:* A. The Perkiomen mine area (Figures 92 and 93) is located on the northwest side of Mine Run, 0.4 mile (0.65 km) northwest of the junction of Mine Run with Perkiomen Creek, Lower Providence Township, Montgomery County. This shaft is located 350 feet (108 m) northeast of Egypt Road and 250 feet (75 m) north of Mine Run (Earl, 1950c). The area around the shaft and dumps is an active archery range.

The Whim shaft area of the Perkiomen mine is located on the southeast side of Mine Run, 0.4 mile (0.65 km) northwest of the crossroads at Audubon and 0.4 mile (0.65 km) northeast of the junction of Mine Run with Perkiomen Creek. This shaft is located 400 feet (120 m) west-southwest of Egypt Road and 175 ± 50 feet (55 ± 15 m) southeast of Mine Run.

The Ecton mine area is located to the east of Mine Run, 0.55 mile (0.85 km) west of the crossroads at Audubon and 0.15 mile (0.3 km) northeast of the junction of Mine Run with Perkiomen Creek. The vertical shaft is located 1500 feet southwest of Egypt Road and 325 ± 50 feet southeast of Mine Run. A crosscut into a stope on the 80 foot (24 m) level of the Ecton mine is located near the east side of Mine Run, 400 feet (120 m) west-southwest of the vertical shaft.

The Wetherill or old Perkiomen mine or United Mine lode area is located 0.7 mile (1.15 km) southwest of the crossroads at Audubon and 0.2 mile (0.3 km) south of the junction of Mine Run with Perkiomen Creek. The shaft was located 125 ± 50 feet (34 ± 15 m) north-northeast of the original home of J. J. Audubon, who managed the mine in the late 1700's for his father.

The locations of these four mines are shown on Plate 6, a copy of portions of the Collegeville and Valley Forge 7½-minute topographic maps. All of the occurrences mentioned above are in Montgomery County.

B.	LATITUDE N	LONGITUDE W
Perkiomen	40° 07′ 56″	75° 26′ 16″
Whim	40° 07′ 50″	75° 26′ 22″
Ecton	40° 07′ 41″	75° 26′ 31″
Wetherill	40° 07′ 22″	75° 26′ 39″

C. TOPOGRAPHIC MAP: The Perkiomen, Whim, and Ecton shafts are located on the Collegeville 7½-minute quadrangle and the Wetherill shaft on the Valley Forge 7½-minute map.

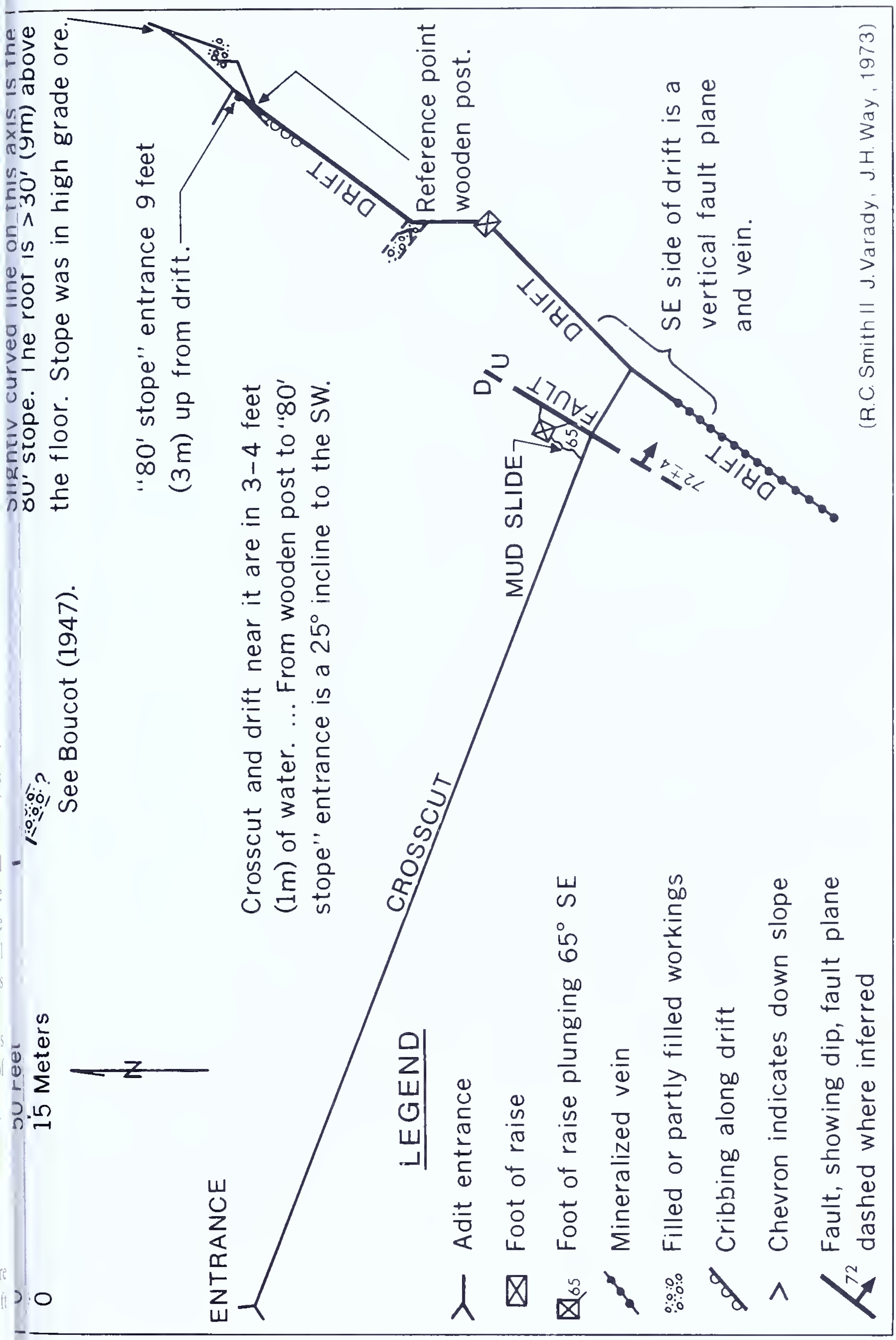


Figure 86. Plan map of portions of 80-foot level, Ecton Mine, Audubon, Montgomery Co.

3. *Host Rock:* Triassic Stockton Formation consisting of red sandstone, siltstone and shale; some of these are arkosic or calcareous (Earl, 1950c). Boucot (1949) reports that core from drilling by the U. S. Bureau of Mines indicates that the Triassic sediments here are approximately 400 feet (120 m) thick, and rest on lower Paleozoic argillaceous limestones. The published drill logs by P. E. Hotz, and A. F. Leonard (Earl, 1950c) do not show this. If, however, Boucot is correct, then the average dip of the Triassic-Paleozoic contact from the south is less than 3°.

4. *Estimated Total Amounts of Ore Metals:*

A.	Perkiomen	Whim	Ecton	Wetherill
<1 g:				
1-1000 g:		Ag		
1-1000 kg:	Zn	Zn	Pb	Cu?, Zn?
>1000 kg:	Pb, Cu	Pb, Cu	Zn, Cu	Pb

Except for the 80-foot stope of the Ecton mine, the above estimates are based on observations of dump material.

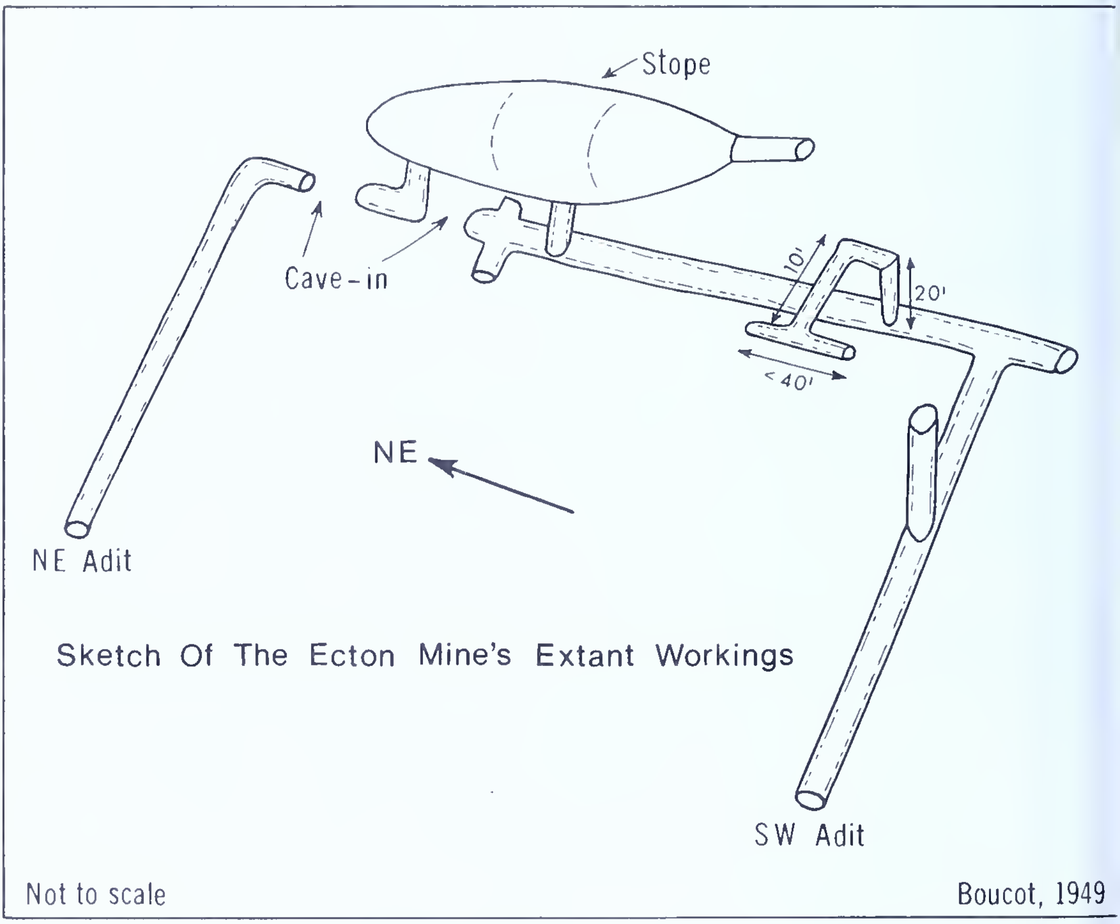


Figure 87. Schematic projection of the 80-foot level, Ecton Mine, Audubon, Montgomery Co.

B. ASSAYS: The 12,200 tons of ore produced from the Perkiomen mine in 1852 yielded 617 tons of concentrate containing 18% Cu, whereas in a prospectus (Remington, 1851) it is claimed that the "ore" itself runs 17 to 18% Cu. Williams (1863) likewise reports 680 tons of copper ore for the year ending April 1, 1852 with 7 to 23% copper recovered. Perhaps something on the order of 100 tons of high-grade (by present standards) lead ore was produced from the four shafts. Assays for silver are not available and the sphalerite, very abundant in the Ecton mine, does not appear to have been recovered, because of a lack of market at that time.

5. *Minerals Observed and Relative Amounts:*

A. ECONOMIC

	Perkiomen	Whim	Ecton	Wetherill (Old Perkiomen)
Major:	Chalcopyrite, galena, malachite	Chalcopyrite, malachite	Chalcopyrite, sphalerite	Anglesite, cerussite, galena
Minor:	Bornite, cerussite	Galena	Galena, linarite, pyrite	
Trace:	Anglesite, azurite, chrysocolla, cuprite, linarite, pyromorphite, sphalerite, wulfenite,[1] smithsonite, pseudomalachite*	Cerussite, linarite, native silver, pseudomalachite* pyromorphite, sphalerite, wulfenite[1]	Anglesite, brochantite, cerussite, chrysocolla, serpierite,* greenockite, hemimorphite, langite,* posnjakite,* pyromorphite, susanite or leadhillite*	Malachite

B. GANGUE

	Perkiomen	Whim	Ecton	Wetherill (Old Perkiomen)
Major:	Quartz, "limonite"	Quartz, "limonite," dolomite (ferroan)	Quartz, "limonite"	"Limonite"
Minor:	Barite, dolomite (ferroan)			
Trace:	Chlorite		Barite	

6. *Paragenesis:* Vein quartz with minor galena near end; ferroan dolomite with galena and sphalerite; chalcopyrite just prior to the end of ferroan dolomite deposition; chlorite and calcite.

1. Tabular, not ditetragonal pyramids as were reported by Boucot (1949) for the Ecton mine.

Figure 88. Looking northwest out of the crosscut toward the entrance (80-foot level) of the Ecton mine, Audubon, Montgomery County. Photo taken near entrance.

7. *Geologic Description:* The four shafts discussed above are located in steeply dipping to nearly vertical mineralized quartz veins occupying faults through nearly horizontal clastic sediments of the Triassic Stockton Formation (Figures 91, 94, 95 and 96). As shown in Figure 86, a tape and compass map of the accessible portions of the 80-foot stope of the Ecton mine, the trend of this portion of the mineralized fault (Figures 86 and 93) was found to be N37E at 3 locations and N35E at one other. Earl (1950c) reports an overall trend for the fault of approximately N40E, and Boucot (1949) reports N35E in the southwest portion of the 80-foot level Ecton drift. The alignment of the Perkiomen, Whim, and the Ecton shafts yields a fault strike of N37E. The Wetherill-old Perkiomen mine is not on this trend. This is in agreement with the map of Rogers (1858, p. 701) which showed a strike of N37E for the Perkiomen-Whim-Ecton vein and a strike of N25-26E for the Wetherill-old Perkiomen mine vein (also referred to as the counter vein of the United mine). Two indefinite veins (shown by Rogers) 0.3 mile (0.5 km) and 0.95 mile (1.55 km) east of Perkiomen Creek trend N21E and N35E. Earl (1950c) reports that the fault-vein dips 65-85SE at the Perkiomen mine, while Boucot (1949) reports a fault-vein dip of 75N(?) for the Ecton mine 80-foot stope. Observations during the present study at this latter location suggest an estimated dip of $85 \pm 5°$ to the SE. Another fault encountered 263 ± 2 feet (80 ± 0.6 m) from the crosscut entrance to the 80-foot stope strikes N30 ± 2E and dips from 68° to 76° to the SE (Figure 86). Based on traditional interpretation of slickensides, it is a normal fault (Figure 96). The raise from the drift shown on Figure 86 was not accessible during the

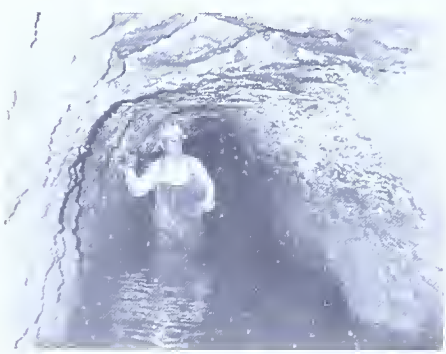


Figure 89. Typical section of 285-foot- (87 m) long crosscut into the 80-foot level of the Ecton mine, Audubon. Near the drift along the vein, a recent mudslide has dammed up the water to over four feet.

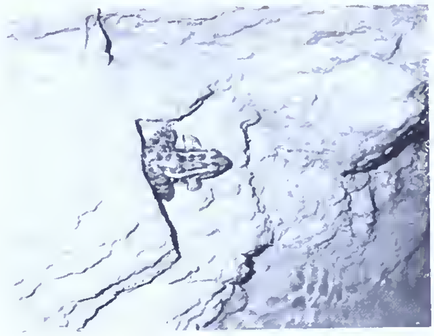


Figure 90. Transient resident of the crosscut entrance to the 80-foot level of the Ecton mine. At times, also occupied by various species of snakes.

present study, but very likely corresponds to the raise-drift-crosscut-drift sketched by Boucot (1949) and here included as Figure 87. According to Boucot, much gossan is present in this small drift. Although Boucot's sketch is definitely not to scale, this small drift may be located in the same fault encountered 263 feet from the crosscut entrance (Figure 86). This small drift may connect with the 65S trending raise. The N30E fault is mineralized with ore in places and barren in others, similar to the main N37E fault-vein. Quartz was the only abundant hydrothermal mineral observed in the 76-foot-(23 m) long drift to the southwest of the N37E fault vein-crosscut intersection (D. Costanzo, personal commun., 1972, determined a length for this end of the drift of 74 feet, while Boucot states it is about 20 feet (6 m) long).

The following distances between surface features were surveyed by D. Costanzo (personal commun., 1972), Earl (1950c), and 1852 and 1863-dated longitudinal sections, Figure 97.

	Costanzo		Earl		1852 Section		1863 Section	
	feet	meters	feet	meters	feet	meters	feet	meters
Perkiomen to Whim shafts	735	224	750	229	720	219	730	223
Whim to Ecton shafts	1,020	311	1,034	315	9,960	3,036	1,040	317
Between crosscuts to Ecton 80-foot stope	243	74	225	69	—	—	—	—

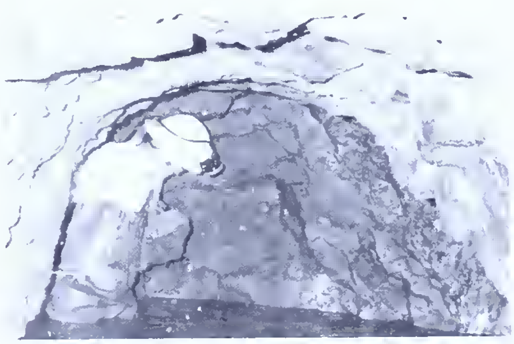


Figure 91. View looking southeast at junction of crosscut and drift. The dark, wet rocks with the sub-vertical fractures in the plane of the photo are in the main fault-vein.

Figure 92. View of Perkiomen-Whim-Ecton mines, Audubon, Montgomery County. (Courtesy of A. V. Heyl, U. S. Geological Survey.)

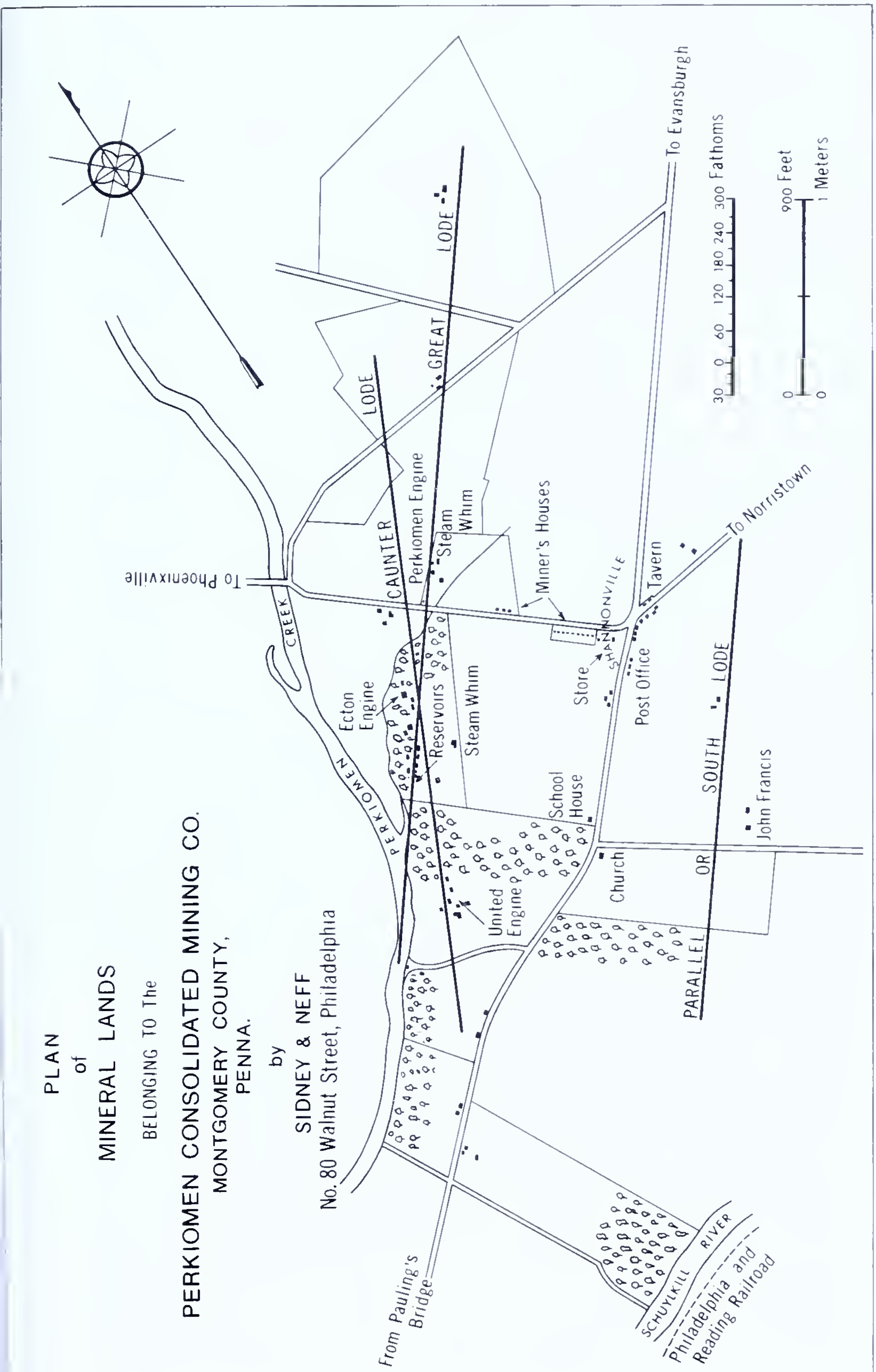


Figure 93. Plan map of veins in Audubon area, Montgomery Co. (Courtesy of E. Graham, Mill Run.)

Figure 94. Looking northeast in 80-foot stope at vertical fault surfaces, some with minor quartz. Note the bent cross prop and the crushed wedge at the geologist's left hand.

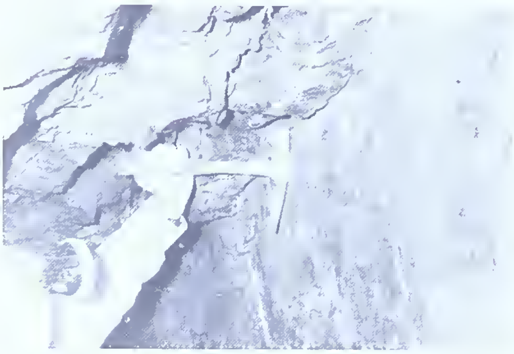


Figure 95. A lean portion of the vein exposed in the southwest end of the drift on the 80-foot level of the Ecton mine. The hammer head is on the fault surface and the handle across the vein, here thin and consisting mostly of quartz gangue.

Figure 96. Vertical, slickensided fault surface cutting horizontal beds in crosscut to 80-foot level, 22 feet (7 m) northwest of the drift. This is the site of recent mudslides from an inclined raise.

The longitudinal section from an 1863 prospectus (Figure 3 of Earl, 1950c) shows a drift on the 240-foot (73 m) level of the Perkiomen shaft connecting with the Whim and Ecton shafts. This may not have been completed. Earl (1950c) reports a total of 6,640 feet (2,000 m) of drifting in the "Perkiomen-Ecton mines." (Figures 97-103) Thus, the area can be expected to be as tunneled as the Etruscan *cuniculli of Veii*. D. Costanzo (personal commun., 1972) furnished a copy of a map of unknown origin, labelled "Old Shannon Mine," which portrays a drift passing beneath the village of Audubon itself.

It appears possible that the Perkiomen-Whim-Ecton vein is zoned both vertically and horizontally. During the present study, sphalerite was observed to be sparse at the Perkiomen and Whim shafts, but common at the

Ecton shaft. Copper was generally reported to have increased at depth relative to lead in the mines. The effect of supergene alteration, mineral collectors, and economics on the development of the apparent zoning must be considered. Prior to 1850, the mines were worked for lead, and after that date for copper.

Wetherill (1827, p. 308-310) described the veins and workings of the old Perkiomen mine (Figure 97) as follows:

> The shaft has been sunk to a depth of 160 feet from the surface. The Upper drift made by the company, has been extended on both sides to a distance of 192 feet. In addition to this drift, two others have been cut parallel to it, one of them opening 115 feet, and the other 150 feet below the surface; each of them has much the same lateral extent as the upper one, and all three follow the direction of the principal lead vein. . . .

Rapid changes in the width, grade, and mineralogy are apparent from Wetherill's vertical and horizontal description of the vein:

> At the depth of 10 feet, the vein increased to fifteen inches in thickness of solid ore, was regularly formed, and inclining 65°.
>
> At 20 feet the vein continued much the same, though rather poor to the south. Specks of carbonate of copper, and oxide of iron, were now first seen. Inclination 85°.
>
> At 30 feet the rock became harder, and the vein poorer; the gangue for the most part consisting of quartz intermixed with copper, pyrites, and iron.
>
> At 40 feet the vein improved to the north, and had sulphate of Barytes in addition to the former Matrix. Inclination 75°.
>
> At 60 feet the Galena diminshed and the salts of lead as the Carbonate and Phosphate, became abundant.
>
> At 70 feet the vein improved, and strings of Blende were discovered; but the water had increased to an inconvenient degree.
>
> The vein now diminished gradually, until at a depth of 82 feet it was considered scarcely worth pursuing in a vertical direction; but the shaft was continued for the purpose of running the drifts. . . .
>
> But a better idea of the veins and their attendant minerals may be obtained by stating the successive products of some one of the drifts; and for this purpose we will take the N.W. course of the Lower drift.
>
> This passage is seventy-two inches high, and forty-two wide. Soon after its commencement, it presents a vein of four feet in thickness, of which the gangue is Quartz and Barytes, with some iron.
>
> The same appearances continue for forty feet, where the vein becomes five feet thick, and has carbonate and phosphate of lead in addition to the former substances.
>
> At 50 feet the vein is three feet across, and is accompanied by sulphuret of zinc.
>
> At 60 feet the vein is five feet through: carbonate of copper and the salts of lead in plenty, with small quantities of carbonate of zinc.
>
> At 70 feet the vein diminished to three feet and a half, but has all the above mentioned minerals.

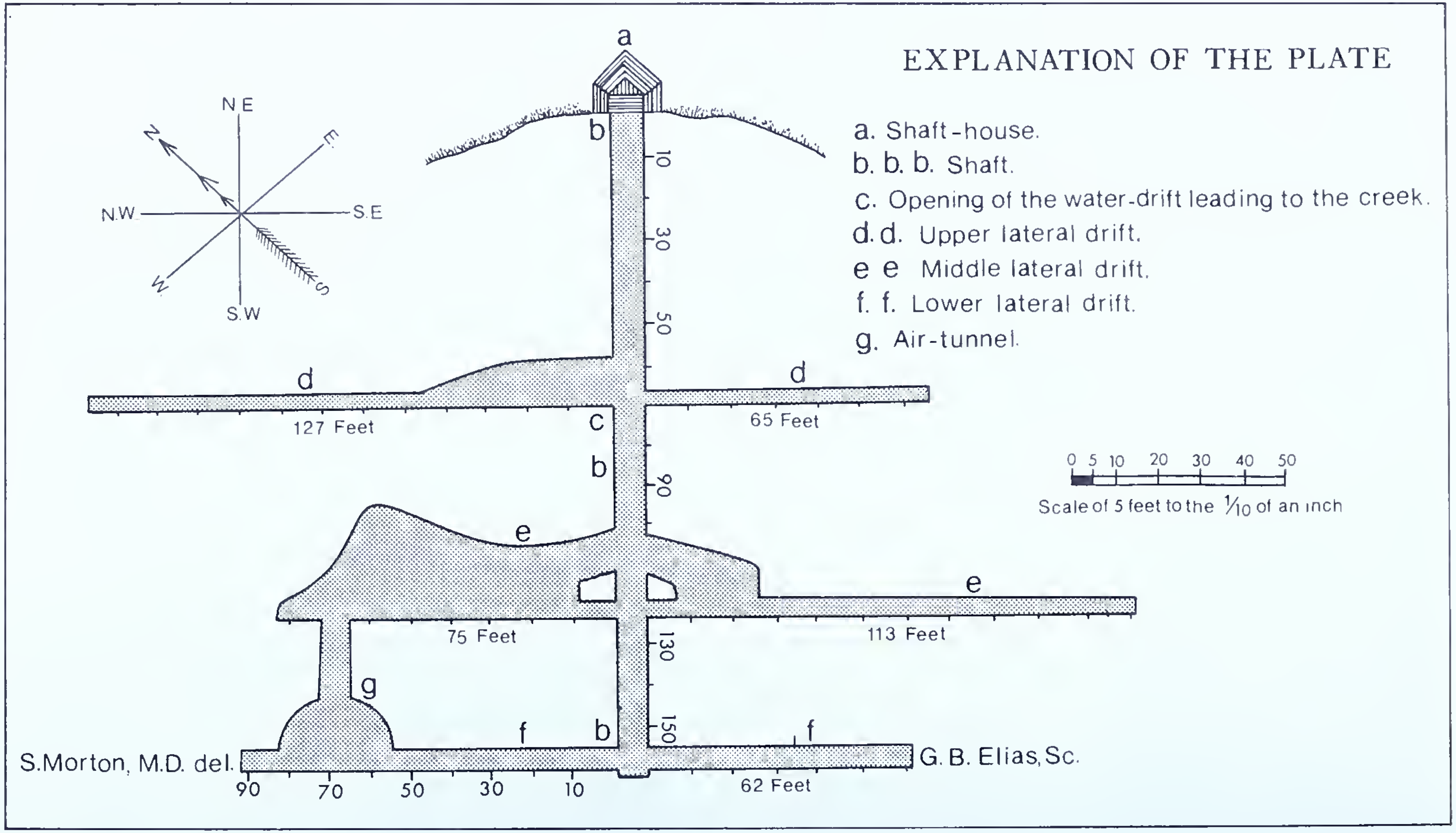


Figure 97. Cross section of the "old" Perkiomen mine, Audubon, Montgomery Co. (Wetherill, 1827, p. 315).

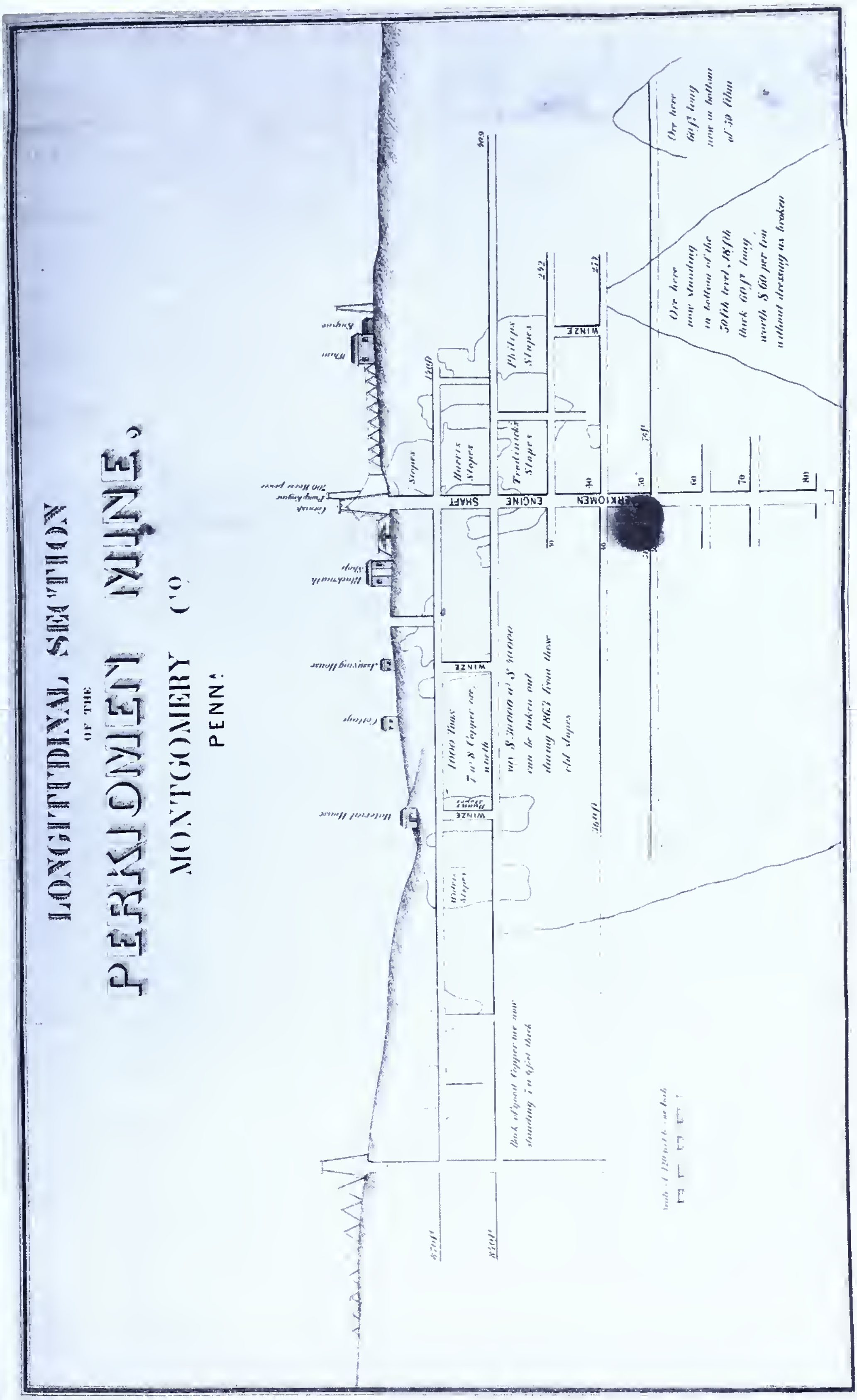


Figure 98. Longitudinal section of the "new" Perkiomen mine and whim shaft (left side), from Williams (1863), (courtesy of A. V. Heyl, U. S. Geological Survey).

Figure 99. Waste rock on rotten wood platform beneath entrance to 80-foot stope from drift.

Figure 100. Geologist suspiciously views rotten lagging and bent roof prop in drift near entrance to 80-foot stope of Ecton mine. Lagging on northwest (right) holds back sheared gangue.

At 90 feet the vein is but thirty inches wide.

After this drift had been run for 60 feet, a rich vein was observed pursuing a vertical course; the excavation was therefore continued upwards, by which means the middle and lower drifts became united by the Air-tunnel.

Williams (1863, p. 12) reported that the vein in the New Perkiomen mine varied from 2 to 20 feet (0.6 to 6 m) thick and "While it has shown itself in many portions exceedingly rich, the ores appear to be very irregularly disseminated, occurring in heavy bunches and masses rather than being uni-

Figure 101. Looking northeast in the 80-foot stope of the Ecton mine, showing former width of vein. A thin veneer of rich ore remains on both walls in many places.

Figure 102. Waste rock on rotten wood platforms above entrance into 80-foot level stope from drift.

formly distributed. . . .the limits of such masses of ore are marked by the occurrence of large deposits of blende." For the Whim shaft of the Perkiomen mine, Williams reported a vein width of 42 inches (1.1 m) with considerable galena and chalcopyrite. In the same prospectus, the former mine captain, Joseph Cocking reported on the levels and ore chutes as follows (Figure 98):

> The ten fathom level, twenty fathom level, thirty fathom level, forty fathom level and fifty fathom level, are all driven long distances east and west of the engine shaft on the course of the lode through rich bunches of ore, from twenty feet to one hundred feet in length,

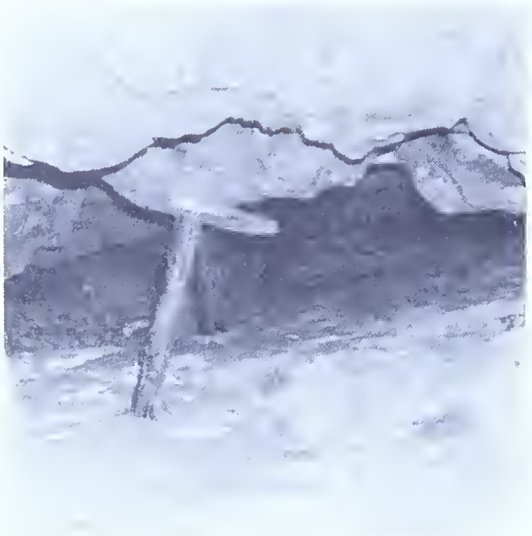


Figure 103. View of several levels of platforms holding waste rock. Looking up in 80-foot stope of Ecton mine.

> and between these bunches there is no standing arches of ground that will yield a large amount of vein-stuff, yielding from five percent to seven percent of copper. I think there can be from one thousand to fifteen hundred tons of ore obtained from these levels alone, that will yield from five percent to seven percent of copper. . . .
>
> In the fourth fathom level east of the engine shaft there was a short bunch of ore not more than twelve or thirteen feet long, and varying in width from ten to eighteen inches, that did not hold up but a few feet above the back of the level, but going down it gradually increased in width and extended in length, and now at the fifty fathom level this same bunch of ore is sixty feet long, and from sixteen to eighteen feet wide, and will yield from eight percent to nine percent of copper as stoped from the lode without dressing; there is also in the forty fathom level west of the shaft a good lode two hundred feet long, that will yield a large amount of eight per cent or ten per cent ore.

If the statement of Boucot (1949) that the Triassic sediments are only 400 feet (120 m) thick and are underlain by Paleozoic limestone is correct, then an exploration effort to locate copper-lead-zinc-silver(?) replacement deposits at the intersection of the Triassic faults with the carbonates may be warranted.

Preston Hotz of the U. S. Geological Survey helped log the U. S. Bureau of Mines drill holes of Earl (1950c). Hotz reported to A. V. Heyl (personal commun., 1950) that the vein as drilled was up to 15 feet wide, that much of the mineralized section logged was not analyzed and that none of the holes reached the unoxidized sulfide zone or even a secondary (supergene) enrichment zone of copper.

46. WHEATLEY-BROOKDALE-PHOENIX VEIN, CHESTER COUNTY

(Former Zinc-Lead Producer)

1. *Name:* The area around the Wheatley mine shafts is owned by Mr. Ted A. Nash, the northern end of the vein by Robert H. Meiers, and the area just south of the shafts by Ramsey(?) Buchannon. The area around the Brookdale mine is owned by the Thompson brothers.

2. *Location:* A. The Wheatley Engine Shaft is located 1725 feet (526 m) southwest of Williams Corner; 90 feet (27 m) S70E of Pheasant Run, the home of Ted A. Nash; and 1720 feet (524 m) southeast of the intersection of Tinker Hill and Creek Roads. The Engine Shaft is 122 feet (37 m) southeast of the vein. Several filled shafts and two caved adits have not been located.

The Brookdale Engine Shaft (Figure 104) is located 3725 feet (1135 m) southwest of Williams Corners, 2550 feet (777 m) south-southeast of Tinker Hill-Creek Road, and 2175 feet (663 m) west of White Horse Road. This shaft is 2076 feet (633 m) southwest of the Wheatley Engine Shaft.

Figure 104. Known to over a century of mineral collectors, the Brookdale stack marks the approximate site of the engine shaft, Phoenixville district, Chester County.

The Phoenix shaft is located 5175 feet (1577 m) southwest of Williams Corners, 3775 feet (1151 m) south of Tinker Hill-Creek Road, and 1475 feet (450 m) northwest of White Horse Road. The Phoenix mine is about 3500 feet (1067 m) southwest of the Wheatley Engine Shaft.

B.

	LATITUDE N	LONGITUDE W
Wheatley Engine Shaft	40° 06′ 20″	75° 31′ 02″
Brookdale Engine Shaft	40° 06′ 03″	75° 31′ 16″
Phoenix mine	40° 05′ 50″	75° 31′ 26″

C. TOPOGRAPHIC MAP: Malvern 7½-minute quadrangle.

3. *Host Rock:* Most of the Wheatley-Brookdale-Phoenix vein is in Precambrian biotite-hornblende granitic gneiss whose foliation strikes S20E and dips at about 35°. The northern part of the vein is in red siltstone of the Triassic Stockton Formation.

4. *Estimated Total Amounts of Ore Metals:*

A.

	Wheatley	Brookdale	Phoenix
<1 g:			
1-1000 g:	V		Ag, Cu
1-1000 kg:	Cu, Ag, Mo, As	Cu, Ag	Zn, Pb
>1000 kg:	Zn, Pb, Cu(?)	Zn, Pb, Cu(?)	

B. ASSAYS: Rogers (1853, p. 380) reports that gossan from the Wheatley vein averaged about 10 oz Ag/ton. Blake (1860, p. 414) reports an average of 26 to 30 oz Ag/ton of galena ore containing 70 to 80% Pb with the range for Ag being 15 to 120 oz. Blake reported that pyromorphite ore yielded about 5 oz Ag/ton, and that 1000 tons of ore (lead concentrates) produced in 1854 averaged 60% Pb. The 1864 report of the New York and Boston Silver-Lead Mines reported eight additional assays of galena ore containing 61 to 76% lead and 12-44 oz silver/ton with a good correlation between the two metals. Wheatley (1855, p. 15) reported a total production of 1600 tons of silver-lead ore (lead concentrates) from the mine bearing his name. Blake (1860) and Silliman and others (1864) estimated a total production for the Wheatley mine of 1800 tons. Intermittent production may have continued to about 1870 (Miller, 1924, p. 24). [It is possible that the Wheatley mine[1] was also reopened from 1917 to 1920; if so, up to an additional 500 tons of high grade ore may have been produced (Bascom and Stose, 1938, p. 125).]

A. V. Heyl, U. S. Geol. Survey, has calculated production from stope maps, assuming a two foot vein of 5% Pb, 7% Zn, 1.4% Cu, and 2 oz Ag/ton of ore mined to a width of 6 feet. Such diluted ore he values at $35/ton. This yields 35,000 short tons ($1,900,000) for the 11 Wheatley stopes, 6000 tons ($200,000) for the 9 Brookdale stopes, and 800 tons ($25,000) for the Phoe-

1. A mine was definitely reopened and ore produced. The uncertainty is whether it was the Wheatley, Chester County or both mines.

nix stopes. Heyl thus obtains a total potential value of stoped ore of about \$2,100,000 and a maximum potential recovery of \$6,000,000 for 3000 feet of vein mined to a depth of 500 feet. This, however, does not compare favorably with the similar New Galena deposit in Bucks County.

Heyl (personal commun., 1976) reports a semi-quantitative analysis indicating 1.0% Fe, .002% Ag, 1.0% Cd, .0015% Ga, .01% Ge, and 17 ppb Hg on pure brown sphalerite from the Wheatley dumps. Similarly, Heyl reported 0.06 ppm Au in ferroan dolomite containing traces of chalcopyrite, galena and sphalerite.

5. *Minerals Observed and Relative Amounts:*[2]

A. ECONOMIC

	Wheatley	Brookdale	Phoenix
Major:	Sphalerite (brown) pyromorphite	Sphalerite (golden-brown and dark-brown), galena (coarse, crystalline and steely fine-grained)	
Minor:	Galena,[3] cerussite	Pyromorphite, chalcopyrite (in quartz and diabase), cerussite, anglesite	Pyromorphite, galena (blebs on and inclusions in tips of drusy quartz crystals), sphalerite (dark-golden-brown)
Trace:	Anglesite, chalcopyrite, malachite, anglesite	Brochantite(?), wulfenite (yellow)	Native silver, linarite, cerussite, anglesite, brochantite(?)

B. GANGUE

	Wheatley	Brookdale	Phoenix
Major:	Quartz (coarse crystalline), ferroan dolomite	Quartz (coarse crystalline and chert-like)	Quartz (coarse crystalline)
Minor:		Ferroan dolomite	Goethite
Trace:	Barite, calcite		

2. Many additional species are reported in the literature, but were not observed during the present study. See J. L. Smith (1855) for a description of the minerals. A. V. Heyl (personal commun., 1976) verified palygorskite, linarite, hemimorphite and smithsonite and observed "copper pitch," wulfenite, cuprite, fluorite, goethite and sulfur at the Wheatley Engine Shaft.
3. Galena was a major ore mineral, but recovery was thorough.

6. *Paragenesis:* For Wheatley mine: brecciation of granitic gneiss, ferroan dolomite and chalcopyrite; quartz (the earliest with chalcopyrite, the latest with galena); galena; sphalerite; supergene minerals as pyromorphite, anglesite, cerussite. The calcite veinlets are later than the ferroan dolomite. J. L. Smith (1855, p. 250) reported that the calcite occurred as a layer on the sphalerite and that the fluorite he observed occurred on the calcite.

7. *Geologic Description:* The Wheatley-Brookdale mine (Rogers, 1858, and Figure 82) vein is reported to vary from 1 to 2½ feet (30-75 cm) in width. In the Wheatley mine, the vein averages 1½ feet (45 cm), and in the Brookdale nearly 2 feet (60 cm), but at the latter it contains more quartz and becomes poorer in grade to the southwest. The vein has an apparent length of more than 4000 feet (1200 m).

The Phoenix mine, the southernmost engine shaft on the vein, had a 90-foot shaft, with about 180 feet (54.9 m) of drifts in either direction along the vein from the bottom of the shaft (Blake, 1860, and Anonymous, 1855). A map for an 1855 prospectus indicates about 60 feet (18 m) of stoping to the north and 50 feet (15 m) to the south.

The Brookdale mine, the middle of the three engine shafts, had a 192-foot (58 m) shaft, a 576-foot (176 m) long adit level beginning about 105 feet (32 m) north of the engine shaft and trending southwest on the vein, and substantial drifts on the 84-foot (25 m) and the 156-foot (48 m) levels (Harvey, 1865, and anonymous section of 1855). Rogers (1858, p. 705) reported stains and spots of pyromorphite, cerussite, and galena for about the first 400 feet from the entrance. Harvey (1865) reported rich pyromorphite near the south end of the adit where the vein was said to be two feet wide and, in agreement with Rogers, noted that the vein improved with depth. The mouth of the adit is now caved, but a small spring above creek level issues from the rubble-filled entrance. The first whim shaft southwest of the engine shaft (205 ± 10 feet = 63 ± 3 m apart) is observable as a sinkhole-like depression between Mine Road and the meadow to the west. The second whim to the southwest corresponds to a dump rich in sphalerite and galena in the gulley.

The Wheatley mine, the northernmost engine shaft, had a depth of 300 feet (91 m) and began 122 feet (37 m) east of the vein surface (Blake, 1860). The adit level consisted of a 410-foot (125 m) oblique cross-cut through red shale to the vein, then 540 feet (165 m) along the vein to the 60-foot (18 m) deep, 120-foot (37 m) long cross cut to the engine shaft, then 194 feet (59 m) from the engine shaft cross-cut southwest along the vein to Whim Shaft No. 1, and finally about 281 feet (86 m) along the vein (Black, 1860, and Rogers, 1858). Harvey (1865, p. 6) noted that ". . .an adit was driven to the mine at the lowest possible point, entering the shaft at a depth of forty-six feet eight inches from the surface. This adit is ninety eight fathoms four feet in length. . . ." Based on the adit's depth and length, it must have trended

almost due east. The workings up to 1855 are shown in Plate 7 as a cross section through the vein from a stockholder's statement dated 1863.

Mine Development

	Workings May 1, 1853 Rogers (1858)		Workings Sept. 1854 Blake (1860)		Workings Oct. 5, 1855 Wheatley (1855)		Workings Mar. 19, 1865 Harvey (1865)
Adit Level	*feet*	*meters*	*feet*	*meters*	*feet*	*meters*	
	1279	390	1325	404	1325	404	Main adit "extended" plus a second, 592 foot (180 m)
10 fathom[4]	935	285	1250	381	1440	439	Plus 974 feet (297 m) of drifts and 730 feet (223 m) of crosscuts including work on main adit
20 fathom	560	171	730	223	870	265	
30 fathom	—	—	477	145	640	195	
40 fathom	—	—	315	96	345	105	
Engine shaft	234	71	300	91	300	91	Plus 174 feet (53 m) of "shafts"

Unmentioned in any of the available reports are: 1) a series of pits or filled-in shafts extending south up the gulley from the Brookdale to the Phoenix engine shafts. These are indicated on Plate 7 and described below, beginning with trail of Mine Road across the N. E. mouth of the gulley as zero feet. 2) Sanderson's shaft, an approximately 50-foot (15 m) shaft about 1000 feet (305 m) southwest of the Wheatley engine shaft and 1125 feet (343 m) northeast of the Brookdale engine shaft.

Distance southwesterly from mouth of gulley (by pacing)		Reference point or size of pit	Distance to next pit to S.W.		Bearing to next pit to S.W.
feet	*meters*		*feet*	*meters*	
180	55	Rich dumps (probably from SW whim of Brookdale adit)	280	85	S30W
500	55	20 × 20 × 5′ (6 × 6 × 2m)	40	12	S62W
515	157	Barbed wire at edge of woods			

4. The ten fathom level (60 feet = 18 m) was 10 fathoms beneath the adit level or about 120 feet (37 m) beneath the surface at the Wheatley Engine Shaft.

540	165	20 × 10 × 4′ (long axis N42E)	75	23	S18W
615	187	12′ dia. × 3½′	180	55	S28W
795	242	12 × 12 × 4′	125	38	S20W (N57E to Thompson silos)
915	279	10′ dia. × 3′	5′	2	(Cannot sight)
920	280	Path	20	6	
940	287	8′ dia. × 3′	220	67	(do.)
1160	354	25 × 25 × 15′ (Phoenix mine)	90	27	
1250	381	Dirt road	—	—	

Ore and gangue minerals were not uniformly distributed within the vein. Blake (1860, p. 416-417) reported that the rich ore occurred in shoots which plunged 45° to the southwest within the vein. These shoots have horizontal cross sections of from a few inches to four or five feet (1.2 or 1.5 m). The ore shoots occurred in bunches, the largest group being encountered near the Wheatley engine shaft. Sections through the vein show the 45SW dip of several of the stopes. Within the shoots, sphalerite was concentrated near the vein walls, whereas the core was filled with galena. Outside the rich shoots, Blake reported that the galena occurred chiefly on the hanging wall. Primary (hypogene) zoning within the vein was also reported by Smith (1855) and Hoofstetten (1855). Smith noted that below 240 feet (73 m), sphalerite, fluorite, and ferroan dolomite became abundant and Hoofstetten similarly reported that at 300 feet (91 m) sphalerite and chalcopyrite increased at the expense of galena.

Zoning of secondary (supergene) lead minerals was well described by Smith (1855, p. 253). He noted that from the surface to 30 feet (9 m), pyromorphite was the major mineral and cerussite and galena minor; below 30 feet the pyromorphite decreased and the cerussite increased; at 120 feet (37 m) anglesite and wulfenite began to appear while the pyromorphite, cerussite, and galena continued; at 180 feet (55 m) the pyromorphite was only in traces, cerussite and anglesite were major; at 240 feet (73 m) the pyromorphite was essentially gone, galena was major, and anglesite minor (Figure 106).

Rogers (1858, p. 383-384) described three small, offset diabase dikes in the Wheatley mine. The offsets indicate that the northwest side of the fault moved at least 18 feet (5 m) to the northeast and 36 feet (11 m) upward relative to the southeast side. The dikes range from about 1 to 3 feet (30 to 90 cm) thick, strike approximately east-west, and are vertical to steeply north dipping. Although appearing rather fresh in hand specimen, a sample

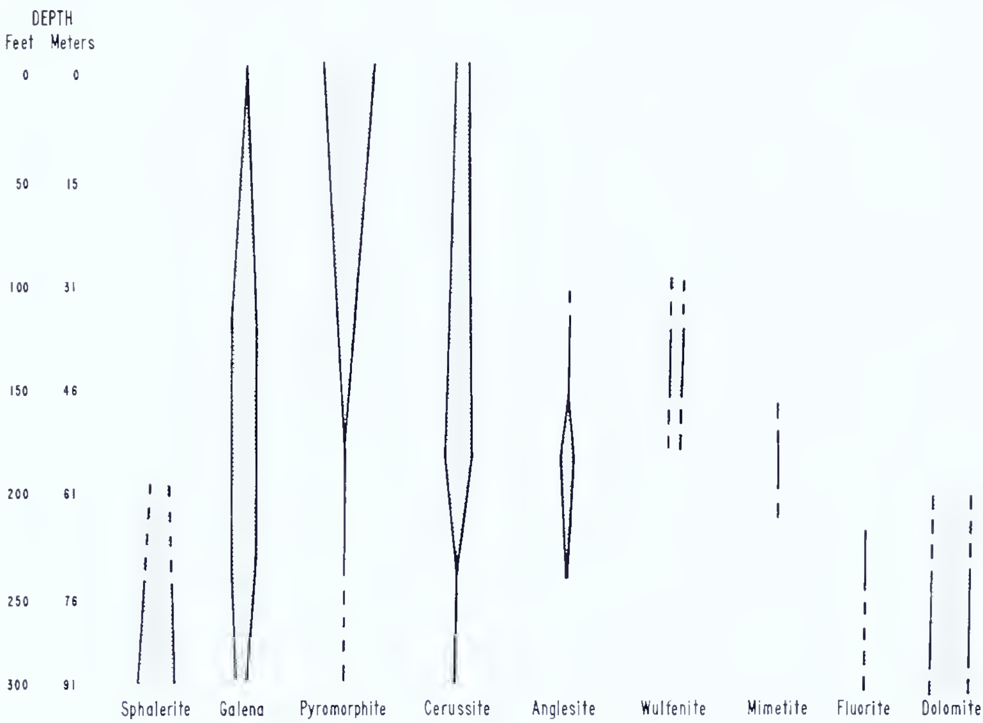


Figure 105. Relative abundance of minerals with depth in the Wheatley mine, Phoenixville, Chester Co. Dashed lines indicate possible continuations beyond the described concentrations. (Adapted from J. L. Smith (1855) and Hoofstetten (1855)).

of this diabase from the Brookdale dumps has a greenish cast in thin section, quite unlike the Triassic diabase dikes. A similar sample from about 0.4 mile east of the Brookdale shaft, contains about three percent TiO_2, a value unlike any chilled diabase from within the Triassic basins (Smith, 1973).

Rogers (1858, p. 386-387) also described a few branch veins from the main lode in the Wheatley mine. These generally intersected the main lode at an acute angle, seldom getting more than 10 feet (3 m) from the main lode. Some of these contained several inches of galena and were mined. The enclosed "horse" between the branch and main veins was itself sometimes streaked with veinlets.

Eight diamond drill holes by the U. S. Bureau of Mines aggregating 2820 feet were described by Reed (1949b). No significant lead-zinc mineralization was found, but the holes may not have been well located. The holes are summarized below.

Hole number	Hole length along 60° incline		Horizontal projection of hole		Horizontal distance from collar to surface of main vein		Drill hole length needed to reach 75° dipping vein with no deviation	
	feet	*meters*	*feet*	*meters*	*feet*	*meters*	*feet*	*meters*
1	144	44	71	22	74	23	108	33
2	409	125	207	63	74	23	108	33
3	437	133	220	67	230	70	315	96
4	369	112	184	56	213	65	292	89
5	378	115	190	58	156	48	210	64
6[5]	324	99	162	49	164	50	227	69
7	320	99	163	50	258	79	227	69
8	433	132	219	67	201	61	300	91

According to Figure 2 of Reed and the author's estimates above, each of the drill holes should have reached the main vein. If, however, either the vein dipped more steeply than 75° at depth or the drill rods "dropped," then holes 3, 4, 6, and 7 were probably too short to reach the vein. The 4.5 feet (1.4 m) of open stope, 5.5 feet (1.7 m) of vein rock, and 0.5 feet (15 cm) of massive coarse sphalerite in the county rock encourage deeper drilling in this limited area. Another drill hole to evaluate possible ore in this area could be placed on the projection of the southwest plunge of the main ore shoot below the level of old workings. This new hole should dip about 75NW and be collared so as to reach the vein about 500 feet (152 m) southwest of the engine shaft at a depth of about 400 feet (122 m).

As at the Chester County mine, the abundance of old shafts and stopes, some extending to the surface, suggests that surface construction should proceed only with extreme caution because of possible cave-in.

5. Stope encountered approximately 208 feet (63 m) beneath the surface.

TRIASSIC (DIABASE ASSOCIATED) OCCURRENCE

47. GRACE MINE, BERKS COUNTY

(Large, Active Iron Mine With Potential Sulfide By-products)

1. *Name:* Grace mine, owned and operated by the Bethlehem Mines Corporation.

2. *Location:* A. The Grace mine magnetite deposit is located 1.5 miles (2.4 km) due north of Morgantown, Caernarvon Township, southwest Berks County. This location is 1.0 mile (1.6 km) south of Joanna Furnace, 1.1 miles (1.8 km) north of Interchange 22 of the Pennsylvania Turnpike, and 1.65 miles (2.6 km) northeast of the end of Interstate 176 onto Pa. Route 23. The entrance shafts are located about 3500 feet (1075 m) southeast of the center of the surface projection of the ore body.

	Approximate Center of Ore Body	Shaft A	Shaft B
B. LATITUDE N:	40° 10′ 36″	40° 10′ 17″	40° 10′ 20″
LONGITUDE W:	75° 53′ 30″	75° 52′ 53″	75° 52′ 56″

C. TOPOGRAPHIC MAP: Morgantown 7½-minute quadrangle.

3. *Host Rock:* Sims (1968) assumed that the host was dolomitic limestone of the Elbrook Formation of Upper Cambrian age based on CaO/MgO ratios.

4. *Estimated Total Amounts of Ore Metals:*

A. <1 g:

1-1000 g:

1-1000 kg:

>1000 kg: Cu, Zn, Pb[1]

B. ASSAYS: See data from Sims (1968) above. The average sulfide concentrate is reported to contain 1.41% Cu, 0.68% Co, 0.26% Ni, 0.22% Zn, and 0.20% Pb. Sims (1968, p. 117) reports that the pyrite contains an average of 0.51% Co. The unrecovered pyrrhotite also may be rich in cobalt. Of the minor base metals, only copper is recovered at the present time (Milton L. Leet, personal commun., 1974).

1. This assumes an orebody with approximate dimensions of 2500 × 1000 × 200 feet (order of magnitude dimensions from Sims, 1968) and ore containing 40% Fe, 0.06% Cu, 0.02% Co, 0.009% Ni, 0.008% Zn, and 0.005% Pb. Such an orebody would contain about 60 million tons with about 4×10^4 tons Cu, 1×10^4 tons Co, 5×10^3 tons Zn and 4×10^3 tons Pb. The total amount of ore could probably double as development continues downdip to the east-northeast. Ore zoning could improve the grades for copper, cobalt, etc. With the exception of iron, copper, and possibly gold, these are not presently recovered because of the economics involved in their separation. Cobalt recovery should possibly be re-evaluated with time because of the critical need and its probable total value at Grace mine of as much as 100 million dollars.

5. *Minerals Observed and Relative Amounts:*

A. ECONOMIC

	In Ore[2]	In Diabase
Major:	Magnetite (dodecahedrons)	
Minor:	Sphalerite (dark-red-brown)	Sphalerite (orange cores and yellow rims, also pale green to colorless. Crystals are tetrahedrons with tristetrahedrons).
Trace:	Galena (rare cuboctahedrons)	

B. GANGUE:

	In Ore	In Diabase
Major:	Calcite (white cleavages)	Prehnite, calcite, tremolite, albite (clear crystals)
Minor:	Antigorite* (white coating on magnetite), pyrrhotite	Datolite* (clear, gray-green veins), leonhardite-laumontite, "mountain leather"
Trace:		Sphene (transparent, orange), apophyllite

6. *Paragenesis:* In diabase: deformation of solidified diabase; albite, tremolite, and sphalerite (orange, then yellow); prehnite, sphalerite (yellow-green), laumontite, apophyllite, and calcite. In ore: magnetite; antigorite; pyrrhotite; dark sphalerite; and calcite. Sims (1968, p. 119) notes that sphalerite and galena were probably contemporaneous with chalcopyrite. He also discusses the paragenesis and mineralogy of the ore in detail.

7. *Geologic Description:* The Grace mine produces magnetite and minor chalcopyrite from a large Cornwall-type deposit. At Grace mine, from less than 50 feet (15 m) to more than 400 feet (120 m) of dolomitic limestone has been replaced along the contact with a Triassic diabase sheet. Sims (1968, p. 113) best described the ore body: "It is roughly tabular in shape, strikes about N60° W, dips 20° to 30° northeast and plunges about 20° N 80° E."

Although zinc and lead are unfortunately not recovered as economic by-products from the ore, Sims (1968, p. 118) described their occurrence: 1) "Sphalerite occurs chiefly as fracture fillings associated with chalcopyrite, but also is present locally in anhedral grains, some with blebs of chalcopyrite. Galena occurs as individual anhedral grains and rims on pyrrhotite grains that are associated with chalcopyrite," 2) Sphalerite and galena seem to follow pyrrhotite with respect to zoning. Pyrrhotite itself is concentrated

2. The sphalerite and galena relative amounts reported here may only represent the 200 and 201 slushing drifts.

near the footwall contact with the diabase, especially along the lower parts of the northwest and southeast extremities of the orebody.

Leet (1973) described large magnetite dodecahedrons in the 200 and 201 slushing drifts of the Grace mine. Examination of the matrix of these specimens revealed dark red-brown sphalerite. Figure 107 shows a plan view map of the area which produced the magnetite crystals showing the occurrence of sphalerite and galena on the west side of the sheet of ore (Figure 107, a and b) near its bottom. The sphalerite and galena occur near the ore-limestone contact about 100 feet (30 m) above the top of the diabase sheet. This bottoming-out of ore before reaching diabase is anomalous.

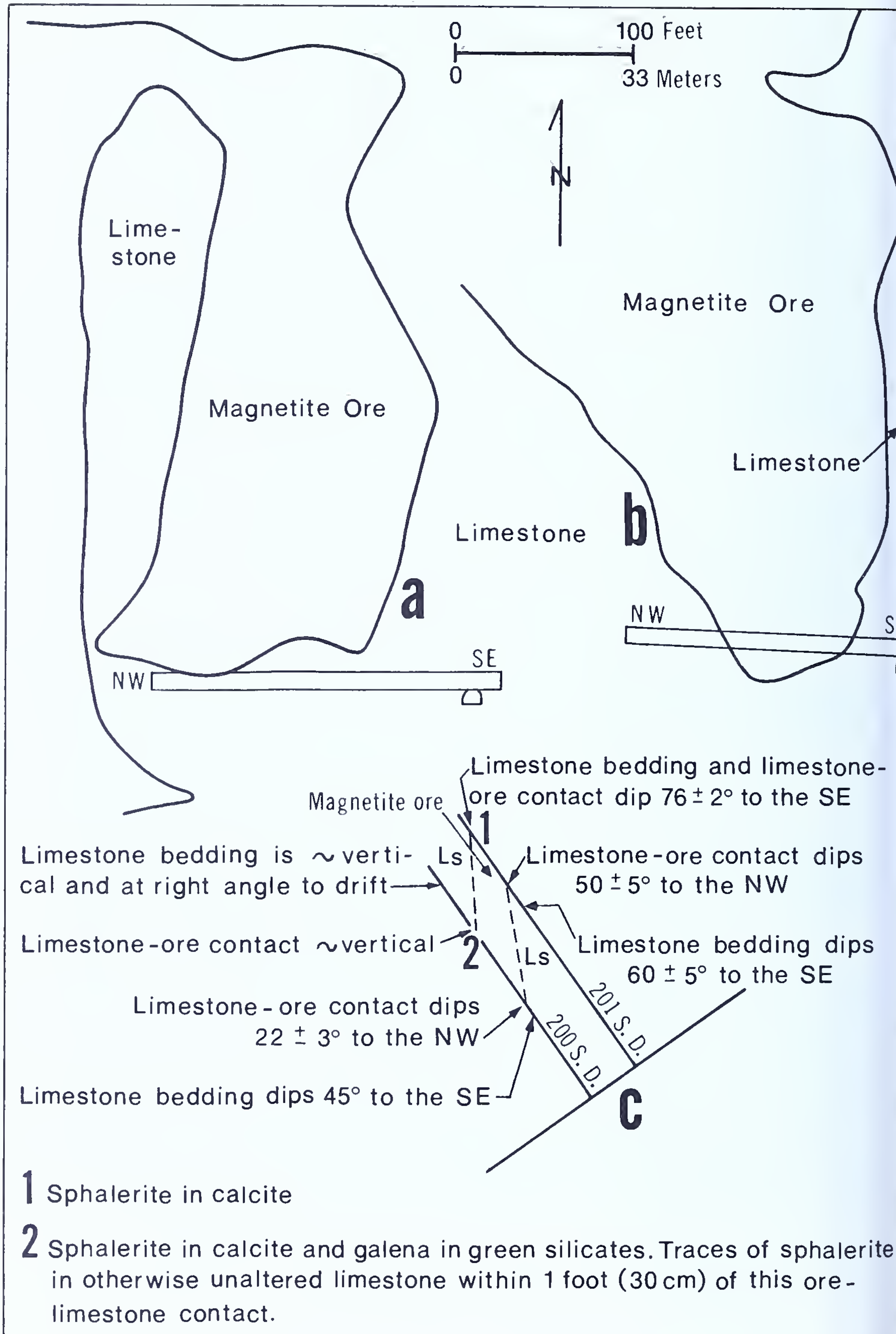
Changes in dip of bedding of up to 45° over a distance of 45 feet (14 m) in slushing drift 200 suggest that ore was localized along a fault. Relict bedding within both the ore and the limestone to the west of the ore slab is approximately vertical. The locus of faulting was probably along the eastern ore-limestone contact and was either vertical or westward dipping. Along the eastern ore-limestone contact, bedding strikes northeast-southwest and ore strikes north-south, suggesting that structure is probably a more important control on mineralization than selective bed replacement. This is also shown by limestone bedding dips of 45° to 65°SE adjacent to an ore-limestone contact dipping 22°-50° to the northwest.

The ore slab is generally sheathed by 6-18 inches (15-46 cm) of soft light-green antigorite with the above-mentioned magnetite crystals growing from the ore into the antigorite. Limestone more than 1 foot (30 cm) from the antigorite sheath generally shows no visible alteration effects. The one observed partial exception is the occurrence of traces of sphalerite in otherwise unaltered limestone within 1 foot (30 cm) of the northwest ore-limestone contact on the southwest side of 200 slushing drift. The dark sphalerite in this drift occurs in ore about 4 feet (1.2 m) from the northwest ore-limestone contact on the southwest side of the drift and is associated with magnetite and pyrrhotite. The galena in this area is concentrated in a nearly vertical serpentine vein which is 2 to 6 inches (5 to 15 cm) wide.

The dark sphalerite on the rim of 2 × 4 inch (5 × 10 cm) calcite eyes in typical magnetite ore two feet (60 cm) from the northwest ore contact on the northeast side of 201 slushing drift is associated with magnetite dodecahedrons and both massive and nodular pyrite.

Galena lumps in silicate gangue from ore have been reported from 41 Panel on the 4th level.

Smith (1973, p. 252) noted bare traces of sphene, pyrite, chalcopyrite, galena and sphalerite in a thin albite veinlet in diabase which trends N90E, 65S. This location is in a roadcut of I-176 just west of the Grace mine, at a point 588 feet (182 m) along the traverse. Other veins contained traces of silver and gold in chalcopyrite. Similarly, a trace of galena* was found at a depth of 1347 feet 6 inches (415 m) in diamond drill core number 26 at the Warwick (Pine Swamp) prospect east of the Grace mine. Samples of ore


0
100 Feet
0
33 Meters
N
Lime-stone
Magnetite Ore
Magnetite Ore
Limestone
Limestone
a
b
NW
SE
NW
SE
Limestone bedding and limestone-ore contact dip 76 ± 2° to the SE
Magnetite ore
1
Limestone bedding is ~vertical and at right angle to drift
Ls
Limestone-ore contact dips 50 ± 5° to the NW
Limestone-ore contact ~vertical
2
Ls
Limestone bedding dips 60 ± 5° to the SE
Limestone-ore contact dips 22 ± 3° to the NW
201 S. D.
200 S. D.
Limestone bedding dips 45° to the SE
c
1 Sphalerite in calcite
2 Sphalerite in calcite and galena in green silicates. Traces of sphalerite in otherwise unaltered limestone within 1 foot (30 cm) of this ore-limestone contact.

from the French Creek iron mines at St. Peters, a few miles east of Grace mine, contain dark-brown sphalerite grains up to $\frac{3}{4}$ inch (2 cm) in calcite with chalcopyrite and pyrite.

Sphalerite in deuteric alteration veins within the diabase occurs at several places in the Grace mine. Samples of sphalerite in datolite from 604E slushing drift, entry 07, and 609 slushing drift, entry 04, were furnished by Bryon Brookmeyer. Similarly, sphalerite in prehnite with leonhardite-laumontite from the 609W ramp (on left rib, going down) about 60 feet (18 m) from the intake intersection were furnished by Milton Leet, Mining Engineer at the Grace mine. With assistance from Leet, sphalerite in prehnite was also collected from the top of the 7U take-up raise on the 6th level. This vein is $\frac{1}{2}$ to 3 inches wide (1.3 to 8 cm), composed mostly of prehnite, and trends N54E, 83N. The diabase host rock to the vein is coarse-grained, suggesting that the occurrence is well below the magnetite ore. Sphalerite and traces of galena along fractures and in veinlets cutting diabase were also observed in the 607E west end manway on the 6th level. The sphalerite here is about 70 feet (20 m) below the ore and occurs with albite, prehnite, chlorite, etc. Across the manway, a 2-inch (5 cm) thick chlorite vein trends N70W, 49N (strike subject to magnetic errors).

Although neither zinc nor lead are recovered from the ore or diabase, the occurrence is of interest as a possible genetic link between Cornwall-type iron-copper contact metasomatic deposits and "Phoenixville-type" Triassic zinc-lead-copper vein deposits.

Sims (1968) gives a more balanced picture of Grace mine orebody, whereas Popovich (1965) and Smith (1973) describe the differentiation of the diabase and Tsusue (1964) discusses certain aspects of the mineralogy.

The assistance of Milton Leet in locating and sampling the underground sphalerite and galena occurrences is gratefully acknowledged.

Figure 106. Sections through the 201 (a) and 200 (b) slushing drifts and plan view (c) of both drifts on the 2nd level of the Grace Mine, Morgantown, Berks Co. (Data and sections courtesy of Bethlehem Mines Corporation.)

CONCLUSIONS

Based on this study, the following conclusions have been reached:

1. The southeastern third of Pennsylvania is a promising area for zinc-lead exploration which uses multiple approaches and does not rely heavily on assumptions derived in other parts of the country. To enhance their favorability, exploration programs should utilize geologic, geochemical and geophysical methods and should be multiply-targeted. Exploration programs should not be the responsibility of a single senior geologist, particularly if he is a jack-of-all-trades. Because of the complexity and variety of geologic settings of mineralization in Pennsylvania a proper and ideal procedural sequence for exploration should be as follows: 1) a target area of a few square miles should be selected and property control obtained; 2) the geology should be mapped in great detail and the aerial photography studied; 3) the stream sediments, waters and selected soils should be sampled and analyzed for zinc, lead and several other elements such as Mn, Fe, Co, Ni, Cu and possibly As, Hg, etc.; 4) geophysical methods such as I.P., E.M., gravity, etc. should be tested; and 5) a few shallow drill holes drilled to verify the geology in critical areas. Following this, the various types of geophysical and geochemical data should be contoured on separate transparent overlays to be used on a brightly-colored geologic base map at the same scale. Expert geologists, geophysicists and geochemists should then be allowed to ponder their data for several days to derive geometric models which could explain their data. Following a group meeting to establish which models best fit the data, a drilling program to test the models should be developed and executed. Drilling should cease only after the odds of missing a large economic deposit have been substantially reduced below their initial levels.

2. Some of the more favorable host rocks to zinc and lead mineralization are tabulated below:

Formation	Lithology	Deposit Type	Favorable Area
Rickenbach	dolomite	collapse breccia	Lehigh, Northampton and Berks Counties
Nittany, Bellefonte, etc. of Beekmantown	dolomite	tectonic or collapse breccia	Blair, southwest Centre and northern Bedford Counties
Tuscarora	"quartzite"	tectonic or replacement of pyritic zones	Huntingdon and Centre Counties
Tonoloway	shaly limestone	replacement of hypersaline-deposited limestone and veins	Columbia, Montour, Northumberland, Snyder, Union and Lycoming Counties

Tomstown-Leithsville-Ledger	dolomite	replacement	Lancaster, York and Cumberland Counties

After completion of field work, it was recognized that the Shriver chert of the Old Port Formation might be a suitable host for economic zinc deposits in central Pennsylvania. This theory has not been evaluated.

3. Representative sampling of limonite and trace-element analyses appear to be a rapid and useful method of locating zinc gossans in the Beekmantown Group of central and eastern Pennsylvania. Geologic uncertainties suggest the wisdom of obtaining samples from the stratigraphically adjacent occurrences as well. In addition to the elements chosen in the present reports, mercury analyses may be useful.

4. Areas which by virtue of outcrop, location or past production deserve diamond core drilling include: A) a few hundred feet southeast to east of the Almedia mine, Almedia; B) the areas to the southwest of the Ueberroth mine and far to the east side of Pa. Route 378 at Friedensville; C) the strike belt of the Nittany Formation west of the Keystone mine, beneath Little Juniata River, and north of Pa. 453 near Birmingham; D) the area of the Mary Isett prospects, Sinking Valley; E) the area immediately east of the Soister mine and possibly the old "Gartland" farm, near Woodbury; F) the area immediately north of the Old Clippinger mine, Cleaversburg; E) to the east of the Scott Smith prospect in the Woodbury prospect area; and H) the east end of the Mapleton railroad cut or angle holes from the Rose Hill shale into the upper Tuscarora quartzite at the head of Beech Run, Hares Valley area. Those exploration companies set on taking a reverse approach to exploration (drill first, then decide if geology is too complex) should consider several hundred feet of drilling at any of these areas where property control is practical. Likely, 1000 feet of core at each of the seven areas would develop a few ore intercepts (ore grade and thickness, but without proof of continuity) sufficient to stimulate a major effort to find deposits of ore of these types.

5. Use of geophysical exploration for certain types of zinc-lead occurrences in Pennsylvania has apparently been very limited and modern instrumentation will probably detect some new targets: A) accurate gravity measurements over potential concentrated deposits as at Friedensville and Almedia, B) I.P., E.M. or other studies to detect sulfides for pyritic zones in the top of the Tuscarora quartzite on the west flank of the Jacks Mountain anticline, Hares Valley, Chester Springs drainage cell numbers 220 and 221, Soister mine and other deposits which may have a good correlation between pyrite and sphalerite content.

6. Use of modern, precise geochemical methods has been limited to a few academic studies and apparently never fully utilized by industry. Geochemical samples need (with some exceptions) to be more representative, more carefully processed and analyzed for more elements by truly quantitative

procedures. With the exception of the recent New Jersey Zinc Company soil study of the Woodbury prospect, all of the past industrial geochemical exploration conducted in Pennsylvania known to the author was doomed to failure for one of the following reasons: inadequate control of sampling, use of interference-plagued or semi-quantitative procedures or lack of meaningful statistical treatment.

Carefully planned and executed stream sediment sampling (each sample consisting of ten sub-samples collected at ten-foot intervals and sample sites 1 kilometer apart) is warranted for portions of Bedford, Blair, Centre, and Huntingdon Counties. Soil sampling is warranted for the areas east of Friedensville, the Isett and Old Clippinger prospects and possibly for selected portions of the Hares Valley area.

7. Extensive near-surface stoping in the Phoenixville and Ecton districts suggests that traditional construction should be avoided over the mine workings and within several hundred feet of the strike of the known veins. As noted by A. V. Heyl (personal commun., 1975), stoping was almost certainly more extensive than indicated on the presently available maps. Foundation drilling on a very small spacing would be necessary to verify the suitability of traditional construction methods.

In a world situation where it is becoming more and more difficult for our nation to depend on foreign sources of critical mineral resources, it would be highly desirable that major ore deposits and high-potential areas should be protected from improper use by land promoters and developers until exhaustion of the ore is proved. Similarly, industry has an obligation to remove as much of the ore as safety permits, not just the more profitable high-grade.

Several of the mineralized areas are sufficiently extensive to suggest the possible need to determine the concentrations of lead, arsenic, cadmium, mercury, among others, in domestic well water. Areas deserving environmental checking include the Milesburg Gap, Mount Eagle, Mapleton and New Galena Reservoirs, Honest Hollow near Birmingham, the western flank of Jacks Mountain in Hares Valley and possibly portions of southern and central Sinking Valley. More precise recommendations will follow the completion of the trace-element analyses of the sphalerite and galena sulfide concentrates.

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APPENDIX I. REPORTED TRACE OCCURRENCES OF ZINC AND/OR LEAD[1]

Location	"Economic" Minerals	Host Rock	Reference
Allegheny Co.			
near Pittsburgh	Galena	?	Genth (1875, p. 11)
Armstrong Co.			
North Vandergrift[2]	Sphalerite, galena(?)	Limy shale below Upper Freeport coal	Lapham and Geyer (1972, p. 33-34)
Pennsylvania Railroad cut at head of Kiskminetas River Vandergrift	Galena, sphalerite	Shale a few feet above Lower Freeport coal	A. V. Heyl (personal commun. to Arthur Montgomery, 2/1/65)
Beaver Co.			
"Hardbottom" on Racoon Creek near Beaver	Galena, sphalerite	Nodules in coal measures	D. L. Oswald (personal commun., 12/16/76)
Bedford Co.			
**Bed of goethite E. of Centerville, Cumberland Valley Township	0.5% Zn in goethite	Near base of Shriver Formation	W. deWitt, Jr. (personal commun., 2/20/74)
Outcrop along Gooseberry Run, NW Hyndman	Galena	Mississippian through Pennsylvanian	W. deWitt, Jr. (personal commun., 2/20/74); deWitt's efforts to confirm the report were unsuccessful

1. Occurrences with a reasonable, but slight chance of indicating a significant prospect in the area have been marked with a double asterisk (**).
2. The locality probably produced wurtzite in siderite nodules as observed by the author in 1973, rather than galena in barite nodules as reported.

Location	"Economic" Minerals	Host Rock	Reference
New Enterprise Quarry at Ashcom	Sphalerite	Milroy Member of Loysburg Formation	Edward Carper (personal commun. 1977)
Berks Co.			
J. T. Dyer quarry	Sphalerite, chalcopyrite, skutterudite	Triassic, York Haven-type diabase	Geyer et al. (1976, p. 38-41) and D. T. Hoff (personal commun., 1976)
Fritz Island Mine	Sphalerite, aurichalcite, galena, bornite, chalcopyrite and chalcocite	Triassic skarn	Eyerman (1889, p. 4) and d'Invilliers (1883, p. 394, 397)
**Rickenbach	Sphalerite	Beekmantown Group	Luther Bieber (personal commun., to Len Gerhart, 1930)
Blair Co.			
Horseshoe Curve near Altoona	Galena	Upper Catskill(?) sandstone	J. H. Way (personal commun., 1972)
Bradford Co.			
————	Galena	Carboniferous sandstone	Genth (1875, p. 11)
Adits, 0.15 mile (0.2 km) SW of and 1.1 mile (1.7 km) SSE of Ridgebury	Galena, chalcopyrite	Catskill Formation	D. L. Woodrow (personal commun., 10/28/74)
Bucks Co.			
Edison quarry	Sphalerite	Lockatong shale	A. I. Clauser (personal commun., 1974)
Butler Co.			
Coal mine, 4 miles (6.5 km) west of Parker	Galena	Carboniferous fire clay	Genth (1875, p. 209)

Location	"Economic" Minerals	Host Rock	Reference
Carbon Co.			
Roadcut Pa. 248, Bowmanstown	Galena	Lower Catskill sandstone	
E side NE extension of Pa. Turnpike near Walksville[3]	Galena, sphalerite, chalcopyrite	Upper Trimmers Rock	Klemic et al. 1963, p. 58 and 90-91)
Railroad cut, east side Lehigh Gap	Galena	Tuscarora-Shawangunk	Miller (1941, p. 447)
Coal strip mine on S side U.S. 209, ½ mile (0.8 km) SW Nesquehoning	Galena	Pennsylvanian coal measures	A. V. Heyl (2/1/65); H. Klemic (personal commun., 6/13/73)
Penn Haven Junction	Clausthalite, uraninite	Clarks Ferry-Duncannon of Catskill	Klemic, et al. (1963)
Butcher Hollow	Clausthalite, uraninite	Clarks Ferry-Duncannon of Catskill sandstone	
Centre Co.			
Skytop	Galena, barite	Tuscarora quartzite	P. D. Krynine (personal commun., to A. V. Heyl)
Bald Hill	Galena	Tuscarora quartzite(?)	Linn (1883, p. 256)
Chester Co.			
Pine Swamp prospect	Galena	Triassic, York Haven-type diabase	R. C. Smith (1973, p. 252)
Keystone Trap Rock quarry, Cornog	Galena, sphalerite	Precambrian gneiss	Lapham and Geyer (1969, p. 56-58)
Phoenixville railroad tunnel	Sphalerite	Triassic sediments	Gordon (1922)

3. Lead isotopic and trace-element data for the galena are available in Klemic (1963).

Location	"Economic" Minerals	Host Rock	Reference
Hopewell iron mine, west of Warwick	Magnetite, sphalerite	Pickering gneiss adjacent to Triassic diabase	Bascom and Stose (1938, p. 122)
Morris mine	Galena, chalcopyrite	Triassic sediments	Gordon (1922, p. 175-176)
French Creek	Sphalerite, chalcopyrite	Triassic skarn	Geyer et al. (1976, p. 77-84)
Clinton-Centre Cos.			
**A. M. DeHass property, Beech Creek	Galena	Tonoloway limestone(?)	Pa. Geol. Survey's mineral collection catalog
Columbia Co.			
Prospect 12	Galena, bornite, chalcopyrite, digenite, covellite, chalcocite	Catskill sandstone	McCauley (1961, p. 31-37 and 58-59)
Dauphin Co.			
Waltonville	Sphalerite, malachite	Triassic sandstone	Stose and Jonas (1933, p. 75)
Delaware Co.			
Glen Mills quarry	Galena	Gneiss	M. L. Anné (personal commun., 1976) and Geyer et al. (1976, p. 114-116)
Sharpless quarry, Glen Mills	Gahnite, beryl	Pegmatite	Gordon (1922, p. 52)
Fayette Co.			
**"Victor" (Hector) Hollow[4]	Galena, sphalerite	Pocono sandstone	Hickock and Moyer (1940, p. 516), Stevenson (1877, p. 109) and (1878, p. 240-241)

4. Included one three-foot (1 m) bed containing 3.4% Zn with 0.3% Pb and about 4 feet of leaner, but mineralized rock. Thus, although exposures were not found to be accessible, more than traces were present. Traces were also reported in the Pocono sandstone along Redstone Creek (Stevenson, 1878, p. 241).

Location	"Economic" Minerals	Host Rock	Reference
Huntingdon Co.			
Water well at Grace Brethern Church Camp, Entriken	Galena	Burgoon sandstone	Ed Koppe (personal commun., 12/28/74)
**Narehood quarry, Stover	Sphalerite	Middle Ordovician limestone	J. P. Ambler (personal commun., 1975)
**Shirleysburg Blacklog Mtn.	Galena(?)	Tuscarora quartzite	Richard Hammon (personal commun., 1973)
Juniata Co.			
W. L. Newman Phosphate mine	?, 0.1-0.2% Zn in bulk samples	Chert of Shriver Formation	Carter (1969, p. 11-12)
Lackawanna Co.			
Scranton	Sphalerite	Pennsylvania coal measures	Eyerman (1889, p. 4)
Lancaster Co.			
**Beartown mine	Sphalerite	Ledger dolomite(?)	Pa. Geol. Survey, mineral collection catalog
Golf course, S side Lancaster	Galena	Ordovician "Conestoga"	Miller (1924, p. 48)
Haldeman Riffles	Galena, "copper ore"		Beck (1952, p. 1) and Frazer (1880, p. 34 and 284)
**Marietta	Galena in limonite	Vintage dolomite(?)	C. Lesley (1856)
Safe Harbor quarry	Sphalerite, galena	Vintage dolomite	Chapman (1950, p. 213), J. H. Way (personal commun., 1974)
**Salisbury Twp.	Galena	?	Mombert (1869, p. 608)
**One mile east of Hermitage, Salisbury Township (same as above?)	Galena	Dolomite(?)	Beck (1952, p. 1)

Location	"Economic" Minerals	Host Rock	Reference
Lebanon Co.			
Cornwall, E end open pit	Sphalerite	"Blue conglomerate"	Lapham and Gray (1973)
H. J. Smith quarry, Fontana	Sphalerite, galena, chalcopyrite	"Blue conglomerate"	Geyer et al. (1976, p. 172-174)
Lehigh Co.			
**Roadcut, S Hozensack	Sphalerite, chalcopyrite magnetite	Triassic conglomerate	A. V. Heyl (personal commun., to Arthur Montgomery, 2/1/65)
**Schneider prospect	Sphalerite	Beekmantown Group dolomite	Edward Newcomb (personal commun. to A. V. Heyl, 1951)
**Quarry at Little Lehigh-Jordan creeks, South Allentown	Sphalerite	Allentown Formation	Miller (1941, p. 449)
**Greene mine, Lanark	Sphalerite(?)	Beekmantown-Jacksonburg	Miller (1941, p. 449)
Luzerne Co.			
Sullivan Trail Coal Co., West Pittston	Sphalerite, millerite	Pennsylvanian coal measures	Northup (1937, p. 1184-1185)
Drill hole, Union Township	Sphalerite	Upper Devonian siltstone	Pa. Geol. Survey mineral collection catalog
Lycoming Co.			
Bald Eagle Valley	Galena	Limestone	Cleaveland (1816, p. 514)
Pine Creek quarry, Jersey Shore	Sphalerite	L. Dev. or U. Sil. limestone	Brian Brubaker (personal commun., 1976)
Adit along Roaring Branch of Lycoming Creek	Galena, sphalerite, chalcopyrite, chalcocite	Upper Catskill	Meyer (1893, p. 194-196)

Location	"Economic" Minerals	Host Rock	Reference
Monroe Co.			
I. Turn's farm, Middle Smithfield Twp.	Sphalerite and "copper"	Bloomsburg red beds	Eyerman (1889, p. 4); White (1882, p. 217)
Montgomery Co.			
**Kober's mine, Sumneytown	Galena, bornite, chalcopyrite, copper	Triassic shale	Gordon (1922, p. 217-218)
Kibblehouse quarry, Perkiomenville	Galena, sphalerite, cobaltite	Triassic hornfels	Geyer et al. (1976, p. 189-192)
**Bridgeport quarry	Sphalerite, chalcopyrite	Ledger dolomite	Lapham and Geyer (1972, p. 121-122)
Northampton Co.			
**Smith quarry along Bushkill Creek	Sphalerite	Dolomite	Lafayette College mineral collection
**Limonite mine on S. vonSteuben farm, Lower Nazareth Twp., Hecktown	Hemimorphite		Eyerman (1889, p. 29)
Philadelphia Co.			
Quarries at Ridge Ave. and School (Schoolhouse?) Lane, Falls of Schuylkill	Galena, sphalerite	Wissahickon gneiss and pegmatite	Gordon (1922, p. 224)
Pike Co.			
Cliffs along Milford Road, Westfall Twp.	Sphalerite(?), galena "copper"	Hamilton sandstone	Eyerman (1911, p. 24); White (1882, p. 196)
S side Roadcut I-84, on SE side Pine Hill, Milford	Sphalerite	Mahantango siltstone	W. D. Sevon, T.M. Berg (personal commun., 1973)

Location	"Economic" Minerals	Host Rock	Reference
Potter Co.			
Harrison Twp.[5]	Sphalerite(?), galena(?)	?	Eyerman (1911, p. 24)
Schuylkill Co.			
Adamsdale	Galena, sphalerite, pyromorphite*	Palmerton sandstone	Lapham and Geyer (1972, p. 129-130)
Coal stripping, Wadeville, near St. Clair	Galena, sphalerite, chalcopyrite, millerite	Pennsylvanian coal measures	D. Schmerling (personal commun., 1976)
Shaft of Philadelphia and Reading Railroad Co., Pottsville	Galena	Pennsylvanian coal measures	Genth (1875, p. 11)
State Game Land, near Pottsville	Galena	Graywacke	D. W. Kohls (personal commun., 10/5/72)
Snyder Co.			
Outcrops in creek, 0.4 mile (0.6 km) NW of Kreamer	Sphalerite	Conglomerate, Ridgley Mbr., Old Port Fm. below Needmore	Geyer, et al. (1976, p. 202)
Union Co.			
**Buffalo Valley	Galena	Tonoloway(?) limestone	Rogers (1858, v. II, p. 460)
Venango Co.			
Oil well cutting, east of Oil City	Galena, sphalerite	?	Gene Williams (personal commun., to A. W. Rose, 1/9/75)
York Co.			
**Christian Miller's well, Frystown (east York)	Galena	Cambro-Ordovician limestone(?)	Sample collected by O. Hall in 1877

5. Eyerman (1889) may have confused this location with the Millview quarry, Sullivan Co., described: a) in this report as a separate chapter, and b) by Platt (1880, p. 80) within his discussion of Harrison Township, Potter County.

Location	"Economic" Minerals	Host Rock	Reference
Frystown (east York, same as above?)	Galena	Carbonate rock	Eyerman (1889, p. 4)
U. S. Route 15 roadcut, Dillsburg	Sphalerite(?), chalcopyrite	Rossville-type diabase	Lapham and Geyer (1972, p. 137-138)
**York area quarries	Sphalerite, galena, chalcopyrite	Cambro-Ordovician limestone	Jandorf (1912)
(Western Pa.)			
Various	Sphalerite, wurtzite, chalcopyrite	Pennsylvanian coal measures	Seaman and Hamilton (1950)

APPENDIX II. TRACE-ELEMENT ANALYSES OF LIMONITE FROM SOUTHEASTERN PENNSYLVANIA

In an attempt to locate additional zinc-lead occurrences in Pennsylvania, a reconnaissance study of the trace-element content of limonite samples was undertaken. The assumptions underlying this study were: 1) that some limonites are gossans from hydrothermal sulfide deposits, and 2) that the gossan-derived limonites should have a distinctive trace-element content. In order to test this approach, limonite samples without visible secondary ore minerals were collected from over and around known zinc deposits, from several areas with favorable stratigraphy or structure and from some randomly chosen limonite pits. Samples were intended to consist of 100 or more one-inch chips, each from a different piece of limonite and collected from all accessible portions of the dump. In most cases, it was possible to fill a "ten pound" bag with such chips. Excess clay was removed by agitating in water prior to crushing. Commercial analyses were sought for Co, Ni, Cu, Zn, As, Ag, and Pb. A few samples with abundant manganese minerals were also assayed for Mn, but this and As analyses were limited by budget considerations. In-house analyses are being considered to reduce the analytical errors and permit comparison on a constant iron content basis. Analyses for Hg are recommended, but unavailable to the Pennsylvania Survey.

The resulting analyses have been grouped by stratigraphic host and within that classification by county (Table 1). Statistical analysis is being delayed until the trace-element data are available for the fresh sulfides. However, the following generalizations appear warranted:

1) For low Mn samples from the Vintage, Tomstown and Leithsville Formations, greater than 0.12% Zn, 100 ppm Pb, or 1 ppm Ag may be indicative of a gossan. For samples with >5% Mn, the anomalous level for Zn may be higher, perhaps about 0.2% Zn.

2) For samples from the Elbrook, Warrior, Gatesburg, Allentown and Conococheague Formations there are few data, but 1000 ppm Zn and 100 ppm Pb may be the lowest levels of interest. Some difficulty may be encountered in deciding if a mine which began in the Allentown actually removed limonite ore from the Beekmantown Group. Choosing an "anomalous" level may in such cases be quite arbitrary.

3) For samples from the Beekmantown Group in central and eastern Pennsylvania, 0.15% Zn suggests zinc mineralization in the general area, as do 200 ppm As, or greater than 0.2 ppm Ag. Nickel may show a weak correlation with zinc mineralization for eastern Pennsylvania (Northampton, Lehigh and Berks Counties) as may slightly high lead (>40 ppm). Galena, it should be noted, has never been verified in the Friedensville district. For central Pennsylvania (Blair, Bedford, and Centre Counties), lead appears to be a useful indicator at concentrations ⩾100 ppm. In central Pennsylvania, several of the better zinc prospects do contain minor to trace amounts of galena.

4) For iron-rich tectonic breccias from the Tuscarora Formation, an iron analysis is particularly important because of the large and variable silica content. Because iron analyses were not available, the anomaly levels chosen below are only approximate. Samples from the Tuscarora with greater than 200 ppm Pb are considered indicative of mineralization. The topographic location of the present exposures of Tuscarora and the absence of limestone permit complete leaching of zinc. Smithsonite does not occur in these prospects. Zinc analyses are therefore useless as an indicator of zinc mineralization. In fact, zinc-free gossans on ridge tops have been traced downhill to where they contain percent level zinc as sphalerite. Similarly, water samples, collected a few hundred feet downhill from zinc-free gossans, were usually found to be very anomalous for zinc. Arsenic (>250 ppm) and copper (>200 ppm) also appear quite useful. This is because of the hypothesized high arsenic content of sphalerites and observed trace tennantite in the Hares Valley area. Barium may be a useful indicator in the Milesburg Gap area, but at present appears to be far more widespread than the zinc or lead.

5) Too few limonites are available from the Tonoloway Formation, but the sample from Logue quarry with 1.7% Zn is certainly indicative of zinc mineralization.

Name and County	Host Rock	Latitude N	Longitude W	Analyzed Elements[1] Co	Ni	Cu	Zn	As	Ag	Pb	Sample (Size[2])	Comments
Duffy, Marietta, Lancaster Co.	Vintage Ꞓ	40°03'53"	76°32'51"	80	125	25	945	65	<.1	60	58	
N. Manor Hill, Lancaster Co.	Vintage Ꞓ	40°01'06"	76°29'19"	10	40	75	1200	320	2.2	880	39	Disseminated sphalerite in same outcrop. Sample contains minor pyrite.
Mud Lake, Lancaster Co.	Vintage Ꞓ	40°03'22"	76°27'09"	290	335	80	1300	10	<.1	50	88	Reported to be Zn gossans by Friedman (1972), but no strong evidence for this.
Grubb Lake Lancaster Co.	Vintage(?)Ꞓ	40°03'36"	76°26'51"	195	215	135	910	10	.1	40	50	Do.
Smyser's Bank, York Co.	Vintage Ꞓ	40°00'46"	76°41'30"	75	355	25	1100	<5	.1	40	185	Reported to contain 15.9% Mn by 2nd Pa. Survey. (.46% Mn)
Moore's Mill, Cumberland Co.	Tomstown Ꞓ	40°06'11"	77°15'33"	130	180	105	680	100	0.32	29		Soft limonite.
Moore's Mill, Cumberland Co.	Tomstown Ꞓ	40°06'13"	77°15'34"	860	130	205	750	1	5.70	<1		Hard, manganese-rich ore. Turquoise nearby.
Reading Banks, Cumberland Co.	Tomstown Ꞓ	40°08'00"	77°06'38"	150	165	90	2100	45	<.1	400	232	(9.8% Mn)
Ege, Cumberland Co.	Tomstown Ꞓ	40°07'42"	77°07'22"	155	160	253	1850	64	0.16	32		
McCarrick, Cumberland Co.	Tomstown Ꞓ	40°06'26"	77°12'13"	415	165	80	970	6	0.19	6		Manganese-rich ore.
White Rocks, Cumberland Co.	Tomstown Ꞓ	40°07'57"	77°05'42"	305	120	55	1100	40	<.1	30	172 (½)	(9.0% Mn)
Wharton mine, Cumberland Co.	Tomstown Ꞓ	40°06'26"	77°13'19"	940	355	350	2100	<5	<.1	40	306 (½)	(25.0% Mn)
Laurel #1, Cumberland Co.	Tomstown Ꞓ	40°02'31"	77°15'45"	335	160	130	2400	<5	<.1	40	101	Zn stream sediment anomalies in area, but may be due to high Mn. (11.6% Mn)

1 Reported in ppm.
2 Chips ~1 inch unless otherwise noted.

Toland, Cumberland Co.	Tomstown Є	40°04'29"	77°13'0"	210	140	330	640	<5	<.1	20	100	Mine workings cut by Medusa's Mt. Holly clay pit. (.92% Mn)
Helm(?), Cumberland Co.	Tomstown(?) Є	40°02'57"	76°26'10"	130	73	65	620	28	0.14	52	90	
Mont Alto #'s 3 to 8, Franklin Co.	Tomstown Є	39°50'49"	77°32'12"	135	75	115	740	65	.3	30	146	Composite sample from several mines.
Newmeyer Lehigh Co.	Leithsville Є	40°30'29"	75°26'23"	35	35	10	75	<5	<.1	20	61	
Miller No. 249, Ring's, Lehigh Co.	Leithsville Є	40°31'55"	75°25'54"	115	105	35	180	55	<.1	30	83	
Wint's, Lehigh Co.	Leithsville Є	40°32'31"	75°23'36"	54	66	9	375	~6	.17	~2	75	
Cressler, Franklin Co.	Elbrook Є	40°00'32"	77°31'34"	690	285	65	510	N.A.	1	60	192	
McHose, Franklin Co.	Elbrook Є	40°00'40"	77°32'49"	160	160	30	370	N.A.	<.1	20	155	
Old Clippinger Cumberland Co.	Elbrook? Є	40°01'54"	77°29'25"	130	97	58	2700	18	0.22	465	75	
Leidy, Bedford Co.	Warrior-Gatesburg Є	40°12'14"	78°25'49"	205	200	50	490	40	<.1	20		
Wo 26, Bedford Co.	Warrior-Gatesburg Є	40°14'42"	78°25'06"	75	105	30	220	95	<.1	40	25	
No. 22, Berks Co.	Allentown (Upper) Є	40°32'04"	75°41'59"	375	115	50	380	N.A.	<.1	30	237	
No. 10=7, Berks Co.	Allentown Є	40°32'10"	75°40'16"	250	215	90	1000	N.A.	<.1	30	187	
Eureka, Berks Co.	Conococheague Millbach Fm. Є	40°14'54"	75"59'26"	195	210	34	655	~10	.07	~6	135	
Muhlenberg, Berks Co.	Conococheague Millbach-Richland Fm. Є	40°19'30"	75°58'22"	62	75	45	430	~ 7	.15	10	50	
Seitzinger, Berks Co.	Conococheague Richland Fm. Є	40°19'56"	75°57'15"	90	86	27	250	~17	0.09	~4	80	

Name and County	Host Rock	Latitude N	Longitude W	Co	Ni	Cu	Analyzed Elements[1] Zn	As	Ag	Pb	Sample (Size[2])	Comment
Ahl, Franklin Co.	Conococheague-Zullinger-St. Paul Є	40°02'28"	77°32'56"	155	185	15	110	N.A.	<.1	70	256	On a fault contact. Some limonite pseudomorphs after pyrite.
Snyder, Bedford Co.	Beekmantown O	40°13'13"	78°25'58"	5	30	15	30,000	<5	3.5	1.97%		Under lease(?).
"Wernersville," Berks Co.	Beekmantown Epler O	40°19'49"	76°05'43"	64	150	15	750	~10	.05	~45	120	
"Sinking Spring," Berks Co.	Beekmantown Ontelaunee O	40°19'12"	76°01'28"	150	305	39	1300	~5	.14	1	105	
Moselem, Berks Co.	Beekmantown O	40°29'26"	75°51'57"	140	200	41	720	<5	0.11	~20	135	
Weaver, Berks Co.	Beekmantown O	40°22'11"	75°47'09"	130	310	40	1900	25	<.1	40	73	Oley Valley zinc prospect nearby.
Manwiller, Berks Co.	Beekmantown O	40°21'26"	75°46'58"	210	450	70	3400	10	.1	50	74	Do.
Henrietta, Blair Co.	Beekmantown O	40°15'39"	78°17'51"	235	315	35	1200	<5	<.1	10	25	Reported to be Zn gossan by A. V. Heyl but no evidence for this. Stream sediment data also negative.
McAlister, Blair Co.	Beekmantown O	40°14'52"	78°17'49"	40	185	25	750	<5	<.1	20	34	Do.
Hoover, Blair Co.	Beekmantown O	40°14'47"	78°17'46"	25	145	20	590	<5	<.1	20	48	Do.
Faulkner, Blair Co.	Beekmantown O	40°15'24"	78°17'51"	55	195	165	705	<5	<.1	20	31	Do.
Red Bank, Blair Co.	Beekmantown O	40°17'07"	78°17'39"	10	165	20	660	45	<.1	120	70	Area is silicified and soil is red. Limonite pseudomorphs after pyrite.
E. Carper, Blair Co.	Beekmantown Bellefonte O	40°20'29"	78°23'57"	5	60	25	7500	20	.2	530	53	Sphalerite in outcrops nearby. Soil data available. Pb may be high from target shooting. John Matthews, owner.

Soister I, Blair Co.	Beekmantown Nittany ○	40°17'13"	78°22'42"	15	40	15	16,000	820	<.1	100	57	Iron mine closed - hit sulfides. Soil data available. Collapse breccia nearby. Oan Kensinger, owner. 920 ppm Mn, 15.7 ppm Cd.
Soister II, Blair Co.	Beekmantown Nittany ○	40°17'15"	78°22'11"	90	45	15	14,500	B50	<.1	150	82	Same location as Soister I, but includes limonite from fields as well as dumps.
Soister III, Blair Co.	Beekmantown ○	40°17'08"	78°22'46"	300	120	20	750	610	<.1	60	75	
Springfield No. 3, Blair Co.	Beekmantown Nittany ○	40°23'42"	7B°16'19"	10	40	20	90	65	<.1	250	112	
Baileyville, Centre Co.	Beekmantown Nittany-Stonehenge ○	40°42'45"	77°59'00"	115	210	29	105	~35	.09	7	109	
Watson, Centre Co.	Beekmantown Upper Bellefonte? ○	40°49'39"	77°43'20"	125	180	23	365	70	0.06	<1		D'Invilliers (1884, p. 252), reported 0.26% ZnO.
Taylor, Centre Co.	Beekmantown (Lower?) ○	40°55'29"	77°42'50"	75	92	19	120	21	0.04	4		
Nigh, Centre Co.	Beekmantown ○	40°56'14"	77°3B'59"	35	50	9	55	6	0.04	<1		
Correll, Lehigh Co.	Beekmantown Rickenbach ○	40°33'35"	75°23'54"	25	15	10	42,000	.18%	.2	60	35	Probably not under lease. USBM RI4180 shows considerable 1-3% Zn.
Old Hartman, Lehigh Co.	Beekmantown Rickenbach ○	40°33'41"	75°24'03"	24	24	21	21,000	375	.17	55	100	Owned by N. J. Zinc Company.
Lake Thomas, Lehigh Co.	Beekmantown Jacksonburg ○	40°33'27"	75°25'09"	460	355	135	.20	~8	0.27	~3	110	Oo.
Greene, Lehigh Co.	Beekmantown ○	40°33'03"	75°25'03"	175	175	58	715	21	.27	~2	115	Oo.
Schneider, Lehigh Co.	Beekmantown ○	40°32'33"	75°27'12"	205	250	30	2100	15	<.1	30	65	Rumored to have been drilled and some sphalerite found. Probably not under lease.
Schneider N., Lehigh Co.	Beekmantown ○	40°32'39"	75°26'59"	160	190	32	1500	18	0.19	~3	90	Oo.

Name and County	Host Rock	Latitude N	Longitude W	Co	Ni	Cu	Analyzed Elements[1] Zn	As	Ag	Pb	Sample (Size[2])	Comment
Miller's No. 236 & 237, Lehigh Co.	Beekmantown ○	40°33'15"	75°23'45"	58	68	43	.115	<10	.14	14	100	Owned by N. J. Zinc Company.
Miller's No. 229, 230 & 231, Lehigh Co.	Beekmantown ○	40°33'09"	75°24'42"	235	200	31	730	14	.20	17	140	Do.
Miller's No. 141, Lehigh Co.	Beekmantown Epler ○	40°33'21"	75°36'22"	100	130	70	940	N.A.	<.1	20	230	Do.
Smoyer's, Lehigh Co.	Beekmantown ○	40°31'37"	75°36'06"	170	135	45	470	~20	<.02	1	145	Do.
Miller's No. 144, Lehigh Co.	Beekmantown ○	40°33'40"	75°35'58"	100	100	30	925	N.A.	0.1	10	386	
Miller's No. 148, Lehigh Co.	Beekmantown ○	40°34'05"	75°35'11"	170	70	40	225	N.A.	<.1	30	253	
Ironton, Lehigh Co.	Beekmantown (Upper?) ○	40°40'18"	75°33'42"	395	425	85	1700	20	<.1	30	193	Owner, Steven Heleva, has refused to lease in past, may reconsider. Section overturned. (1.35% Mn)
Miller's No. 28, Lehigh Co.	Beekmantown (Lower) ○	40°38'20"	75°32'27"	295	155	25	300	N.A.	2	30	235	
Ritter's, Lehigh Co.	Beekmantown (Upper?) ○	40°40'30"	75°33'21"	300	420	25	1700	30	<.1	20	101	Drilled approx. 1949. Owner claims to have refused $40,000 after drilling. Hole approx. 1000' deep drilled approx. 75' W of mine and one 1200' deep to N of mine.
Miller's No. 14, Lehigh Co.	Beekmantown or Allentown ○	40°38'50"	75°30'55"	90	145	30	510	N.A.	<.1	30	317	
P. Steckles E., Lehigh Co.	Beekmantown (Upper?) ○	40°40'38"	75°32'24"	80	140	26	1400	~3	.10	16	93	Offer said to have been made after drilling. Coplay Cement now owns area.
Miller's No. 7, Lehigh Co.	Beekmantown Epler-Rickenbach ○	40°30'02"	75°41'31"	215	110	85	225	N.A.	<.1	40	303	

P. Steckles W., Lehigh Co.	Beekmantown o	40°40'39"	75°32'36"	97	195	61	.3025	7	.06	35	91	
E. of Simon Ritter's, Northampton Co.	Beekmantown o	40°41'09"	75°21'51"	135	175	15	510	65	<.1	20	106	Limonite somewhere in area reported to contain 0.75% Zn (A. V. Heyl, personal communication, 1975).
O. Pharo, Northampton Co.	Beekmantown o	40°41'10"	75°22'03"	51	58	23	185	48	.05	1		
Miller's No. 7, Northampton Co.	Beekmantown Epler o	40°40'32"	75°23'44"	105	150	40	560	N.A.	<.1	30	194	
Miller's No. 10, Northampton Co.	Beekmantown Epler-Rickenbach o	40°40'02"	75°23'14"	115	180	20	650	N.A.	<.1	20	152	
Miller's No. 11, Northampton Co.	Beekmantown Epler o	40°39'52"	75°23'52"	300	240	20	1400	N.A.	<.1	30	200	
Railroad, Franklin Co.	St. Paul o	40°03'35"	77°51'35"	40	140	75	575	15	<.1	20	84	Host is limestone, not Reedsville or Bald Eagle as mapped by Okuma (1970).
Old Carrick, Franklin Co.	St. Paul o	40°03'27"	77°51'47"	60	215	30	705	<5	<.1	20	134	
Bald Eagle, Centre Co.	Bald Eagle o	40°49'22"	77°59'09"	20	10	25	70	55	<.1	<10	27	
Curtin Gap, Centre Co.	Tuscarora s	40°57'14"	77°43'49"	15	5	110	55	340	.5	.30%	27	
Hannah, Centre Co.	Tuscarora s	40°45'28"	78°05'30"	20	<5	275	75	105	.2	120	17	
Trczlyulny, Centre Co.	Tuscarora s	40°56'03"	77°46'08"	5	15	950	115	.50%	1	.62%	20	Based on abundant float, the "vein" must be at least 3' wide. Au N.O.
MOK No. 4 Centre Co.	Tuscarora s	40°56'48"	77°44'39"	<5	<5	255	105	500	<.1	680	15 (1½)	
MOK No. 5, Centre Co.	Tuscarora s	40°56'29"	77°44'59"	25	25	85	135	70	<.1	620	19 (1½)	

Name and County	Host Rock	Latitude N	Longitude W	Analyzed Elements[1] Co	Ni	Cu	Zn	As	Ag	Pb	Sample (Size[2])	Comment
MOK No. 6, Centre Co.	Tuscarora S	40°48'52"	78°00'48"	<5	<5	50	40	50	<.1	60	24 (1½)	
MOK No. 7, Huntingdon Co.	Tuscarora S	40°44'59"	78°06'12"	<5	<5	130	50	20	.2	100	15 (1½)	
Lick Run Gap, Centre Co.	Tuscarora S	41°00'26"	77°38'28"	8	10	89	40	240	0.12	12		
Shaughnessy, Huntingdon Co.	Tuscarora S	40°24'56"	77°55'07"	<5	10	200	30	330	0.6	130		
No. 4049, Huntingdon Co.	Tuscarora S	40°20'00"	77°57'41"	<5	<10	108	22	1000	< 1	900		(Hg 0.05 ppm)
No. 4100	Tuscarora S	40°19'36"	77°57'43"	5	< 5	75	60	.13%	0.1	130		(Hg 0.05 ppm)
No. 4132	Tuscarora S	40°23'55"	77°55'39"	14	13	202	24	700	< 1	70		(Hg 0.26 ppm)
No. 4133	Tuscarora S	40°23'58"	77°55'37"	19	15	320	69	780	3	210		(Hg 10 ppm)
No. 4134	Tuscarora S	40°24'27"	77°55'21"	14	18	136	27	545	< 1	90		(Hg 0.24 ppm)
Buck Ridge Bedford Co.	Keefer S	39°49'03"	78°31'01"	15	55	20	100	70	<.1	30		
Eldorado Quarry, Blair Co.	Tonoloway S	40°27'42"	78°25'21"	35	190	80	1500	45	<.2	20		
Altoona $BaSO_4$, Blair Co.	Tonoloway S	40°27'22"	78°25'16"	75	250	35	1000	40	<.2	20		Sample consisted mostly of barite with lesser limonite.
Logue Quarry, Lycoming Co.	Tonoloway-Keyser DS	41°14'51"	76°56'37"	20	15	205	17,000	720	3.0	370	10	Sample contained possible hemimorphite crystals.
No. 4050	Oriskany D	40°20'36"	77°58'12"	<5	<10	34	77	45	<.5	15		(Hg 0.69 ppm)

APPENDIX III. EXPLORATION OF THE WOODBURY PROSPECT, BEDFORD COUNTY[1]

by

The New Jersey Zinc Company
Charles G. Van Ness, Project Geologist

In April 1973, an article by Robert C. Smith, II, appeared in *Pennsylvania Geology* reporting on zinc-lead mineralization in northern Bedford County. Examination of our file data indicated no previous inspection. Dr. D. W. Kohls, R. C. Gilbert and C. G. Van Ness inspected the locality and found zinc and lead mineralization in a dolomite breccia scattered over two areas separated by 1,000 meters along strike. Selected samples were estimated to contain 5-10% combined zinc and lead. It was decided to approach the property owners and investigate county records to determine the lease potential. The task force initiated leasing the same day.

Following leasing of 2,431 acres, a geochemical reconnaissance along selected roads in Bloomfield Township was directed by Dr. D. W. Kohls. The purpose was to quickly outline the northern extent of the lead-zinc mineralization observed in a linear gossan-marked feature running from the Jacob Snyder farm northward to the Elwood Smith farm. Soil samples were collected from the B soil horizon at a depth of 2 feet at intervals of 0.1 mile. Cold extractable heavy metals (Cu, Pb, and Zn) were semi-quantitatively determined in the field using the procedure of Bloom (1955). The color of the resulting dithizone solution was plotted on the appropriate 7½-minute topographic map. The highest concentrations of heavy metals in the soil were found north of Barley Church, where the mineralized lineament crossed Pa. Route 867. Other soil anomalies were found 0.15 mile SE of Maria spring, 0.90 mile SE, 0.55 mile S, 0.60 mile W, and 1.0 mile W, at Barley Church, 0.15 mile NW, up to 0.25 mile NNE, 0.60 mile ENE, and 1.40 miles NNW; six of thirteen samples centered 1.60 miles ESE of Lafayetteville; three samples 2.00 miles SE of Lafayetteville; one sample 0.40 mile N of New Enterprise and two samples 1.00 mile N of New Enterprise and three scattered samples from New Enterprise west to Brumbaugh. Because of the semi-quantitative nature of the test used, only the high anomalies near Barley Church were considered further.

A program of geologic mapping was instituted to determine the host lithology and structure. Reconnaissance mapping in Morrison Cove covered an area 16 × 4 miles (21.8 × 5.4 km), the long axis extending from north of Roaring Spring to Salemville.

1. Condensed by paraphrase and quotation with permission from a copy of the summary report by C. G. Van Ness to Dr. F. H. Main, President, The New Jersey Zinc Exploration Company, November, 1974.

> Within a short time, observations of the geology conflicted with interpretation of the Pennsylvania Geological Map (Gray and Shepps, 1960). Generally speaking, the structure mapped by New Jersey Zinc is a doubly plunging dome, overturned and thrust on the west flank. The core of the antiform exposes the Warrior Formation. Exposures appear sequentially and structurally normal except on the west, along Dunning Mountain. Here, the beds are overturned and complexly thrust, bringing the Beekmantown in contact with Reedsville in places, the entire middle Ordovician sequence . . . as well as the Gatesburg are faulted out.

Disseminated sphalerite was found in a zone near the top of the Beekmantown Formation about 30 meters below the gradational contact with the Trenton. Sphalerite in chert nodules at this horizon was noted in the state highway quarry east of New Enterprise and in Pa. Route 36 at Roaring Spring.

> The host for mineralization on the Snyder prospect is probably highly fractured Beekmantown. A large outcrop on the Elwood Smith farm shows the crushed and fractured breccia developed in what is thought to be Beekmantown.

Because of the paucity of outcrop, a geochemical soil sampling program was initiated on the permitted property. A grid was laid out, samples were to be collected on 200-foot (61 m) centers along east-west lines spaced every 500 feet (152 m) along the north-south trend.

Samples were collected from the B horizon using a ⅝-inch (1.6 cm) carbo alloy ships auger, an auger extender and a brace. B horizon intervals were determined visually. A total of 1,021 samples were collected from the grid and each analyzed for zinc by atomic absorption and for lead by a colorimetric procedure. A reference sample, known to be moderately anomalous, was introduced into the unknown series and acceptable reproducibility obtained.

In addition to the routine zinc and lead analyses, eighty samples from traverses 15S and 60S passing through the known mineralization were analyzed for mercury and cadmium. The correlation of Hg, Pb and Zn is shown in Figures 108, a and b. Mercury analyses showed an excellent correlation with lead and zinc.[2] Cadmium contents appear almost random. Hg and Cd were not found to offer advantages over zinc and lead.

Two discrete zinc-lead soil anomalies (see Plate 8) were found within the sampling grid. The anomalies are elongate north-south and are aligned along the Beekmantown-Warrior fault contact. Prominent zinc anomaly drainage trains were found downstream from where streams crossed the anomaly.[3] Anomalies on the Claar farm, in particular, appear unrelated to mining contamination.

2. The present author would extend the mercury analyses east in search of a larger, more broad and diffuse anomaly possibly related to a larger reservoir in the thrust at depth.
3. Could the drainage pattern be controlled by fault breccia zones as well as the mineralization itself?

Semi-quantitative emission spectographic analyses (D. W. Kohls, June 11, 1973) of impure sulfide concentrates from crushed recemented dolomite breccia yielded the following:

	Red Sphalerite E. Smith Farm	Yellow Sphalerite J. Snyder Farm	Galena J. Snyder Farm
Zn	>10%	>10%	>10%
Fe	1-10	1-10	0.1-1
Si	1-10	10	1-10
Al	1	1-10	0.1-1
Cd	0.1-1*	0.1*	0.01
Mg	0.1-1	1	0.1-1
Ca	0.1-1	1-10	0.0-1
Cu	0.01-0.1	0.001-0.01	0.001
Sn	0.01-0.1*	0.1*	0.01
Ge	0.01-01*	0.01	0.0001-0.001
Ga	0.01-0.1	0.01-0.1	0.01
Pb	0.001	0.01	10
Hg	0.01-0.1*	0.01*	N. D.
B	0.001-0.01	0.001-0.01	N. D.
Ni	0.001-0.01	0.0001	N. D.
Cr	0.001-0.01	0.001	0.001
Ag	0.0001-0.001	0.0001-0.001	0.001
Mo	0.0001-0.001	0.001-0.01	N. D.
In	N. D.	N. D.	0.001-0.01

Analyses marked with an * seem significantly high to the present author. Further study by the Pennsylvania Survey of similar samples from all such occurrences is in progress.

The contents of Cd, Sn, Ge and especially Hg seem interestingly high even for sphalerite concentrates. Some similarities exist with the trace-element associations in the sphalerites from the Kentucky-Illinois fluorspar district. Mercury contents of a few hundred to a few thousand ppm should permit detection of even deeply buried ore zones if such exist.

Six diamond drill holes (Plate 8) totaling, 2,092 feet were cored and logged, partly by A. M. Schloss. Upon completion of each drill hole, cemented plugs were carefully set at openings and at the collar to seal the holes. The holes are summarized below in table form and in Figures 109 and 110 in schematic cross section.

Hole No.	Location	Depth	Results
1	65S 11W	396′	Scattered traces $ZnS+CaF_2$
2	57S 16W	386′	Scattered traces ZnS+PbS
3	58S 14W	400′	Scattered traces ZnS+PbS
4	58.5S 12W	401′	Scattered traces ZnS+PbS
5+	58S 14W	203′	147-157′ 0.37% Zn, 0.06% Pb
6	15S 1W	306′	Scattered traces ZnS

+ Bearing N45W, −45° inclination. All other holes vertical

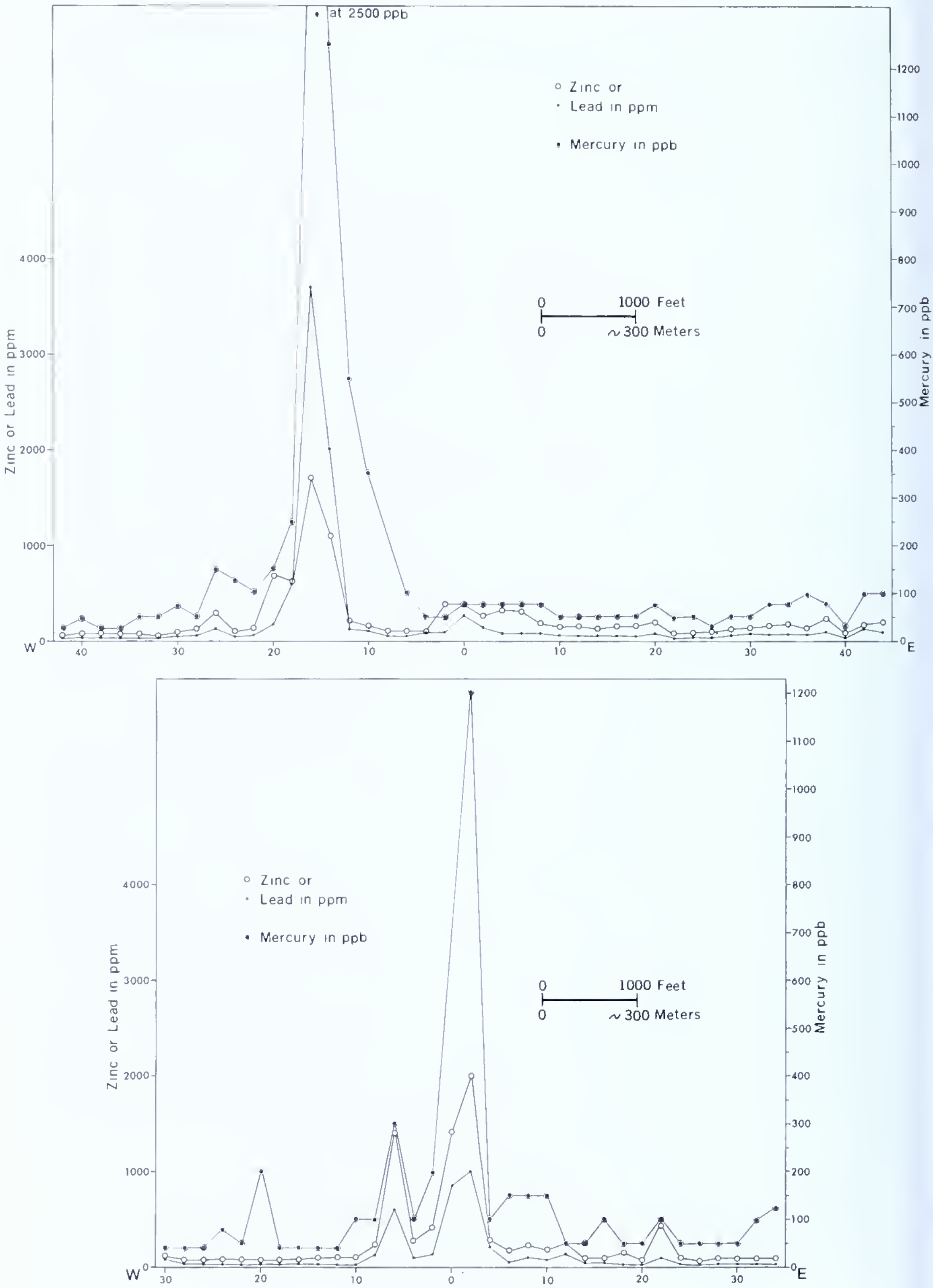


Figure 107. Plots of zinc, lead, and mercury contents of B-zone soils from traverse 15 S through Scott Smith prospect area (A) and traverse 60 S through S. Snyder Shaft area (B), Woodbury prospect, Bedford Co. (Data courtesy of The New Jersey Zinc Co.)

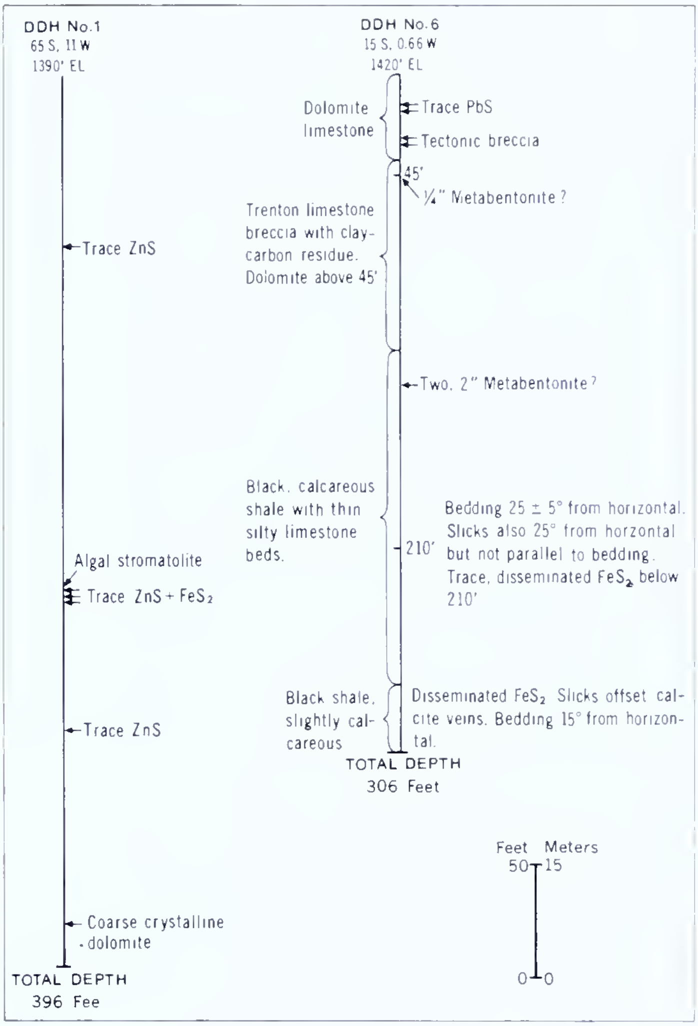


Figure 108. Data from diamond drill holes 1 and 6 from the Woodbury prospect, Bedford Co. (Data courtesy of The New Jersey Zinc Co.)

> The intensity of mineralization found in the logging of the vertical holes probably could not produce the extremely large high-grade soil anomaly. . . . It is difficult to explain away the intense soil anomalies on the basis of the mineralization found in drilling. No instances of subsequent crushing of the sulfides in the breccia matrix were noted. This strongly suggests a much later date of mineralization than traditionally accepted for eastern Pennsylvania or Tennessee.

The concentration of the best mineralization in a restricted zone of a fault plane distinctly limits the potential for ore in the district.[4] The late date of mineralization suggests little relation to the producing mines in the Ordovician carbonate rocks of the eastern United States.

4. The present author agrees with the apparent late age of mineralization in the Woodbury district, but notes apparent "ore" in a simple structural setting at the Soister mine 4.5 miles (7 km) to the northeast.

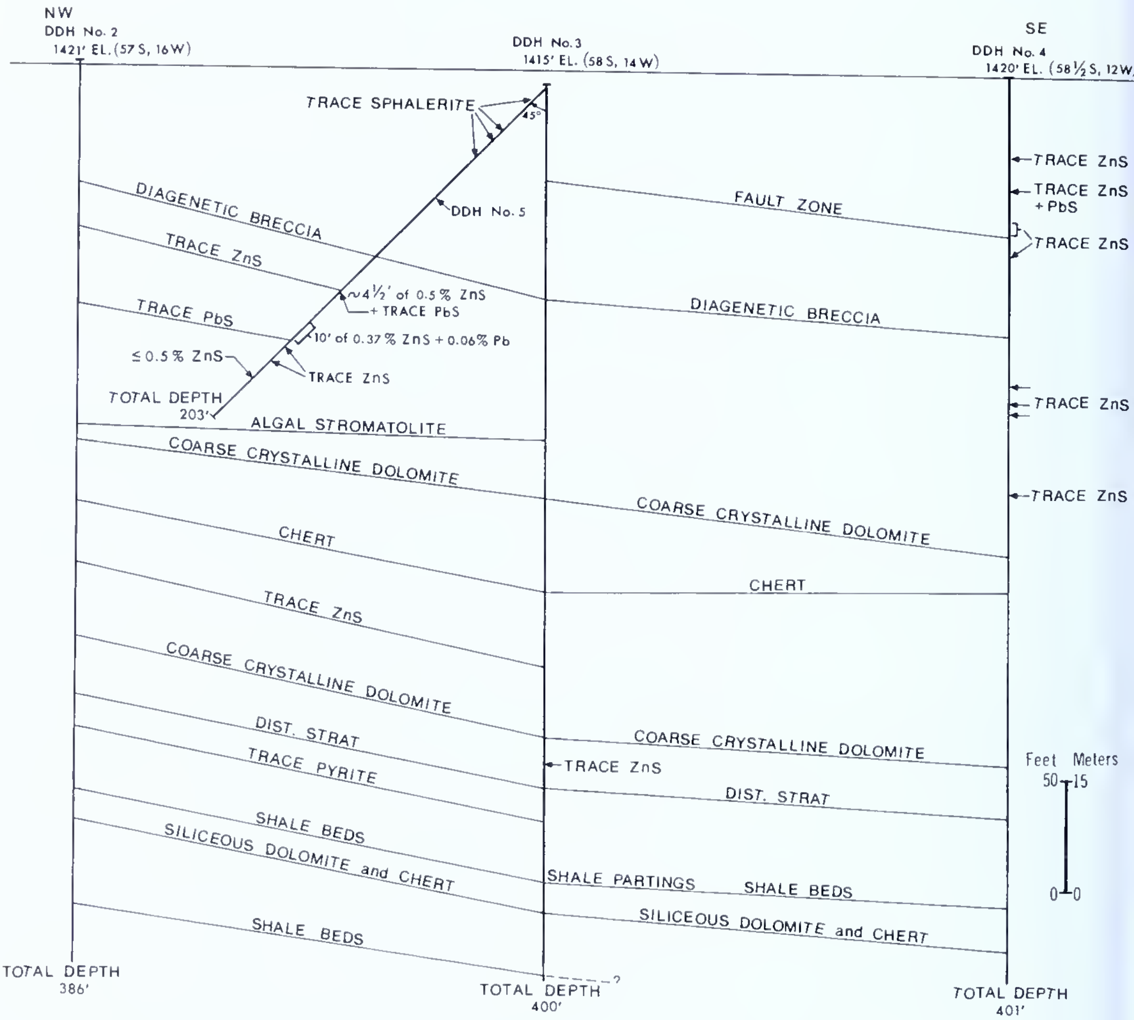


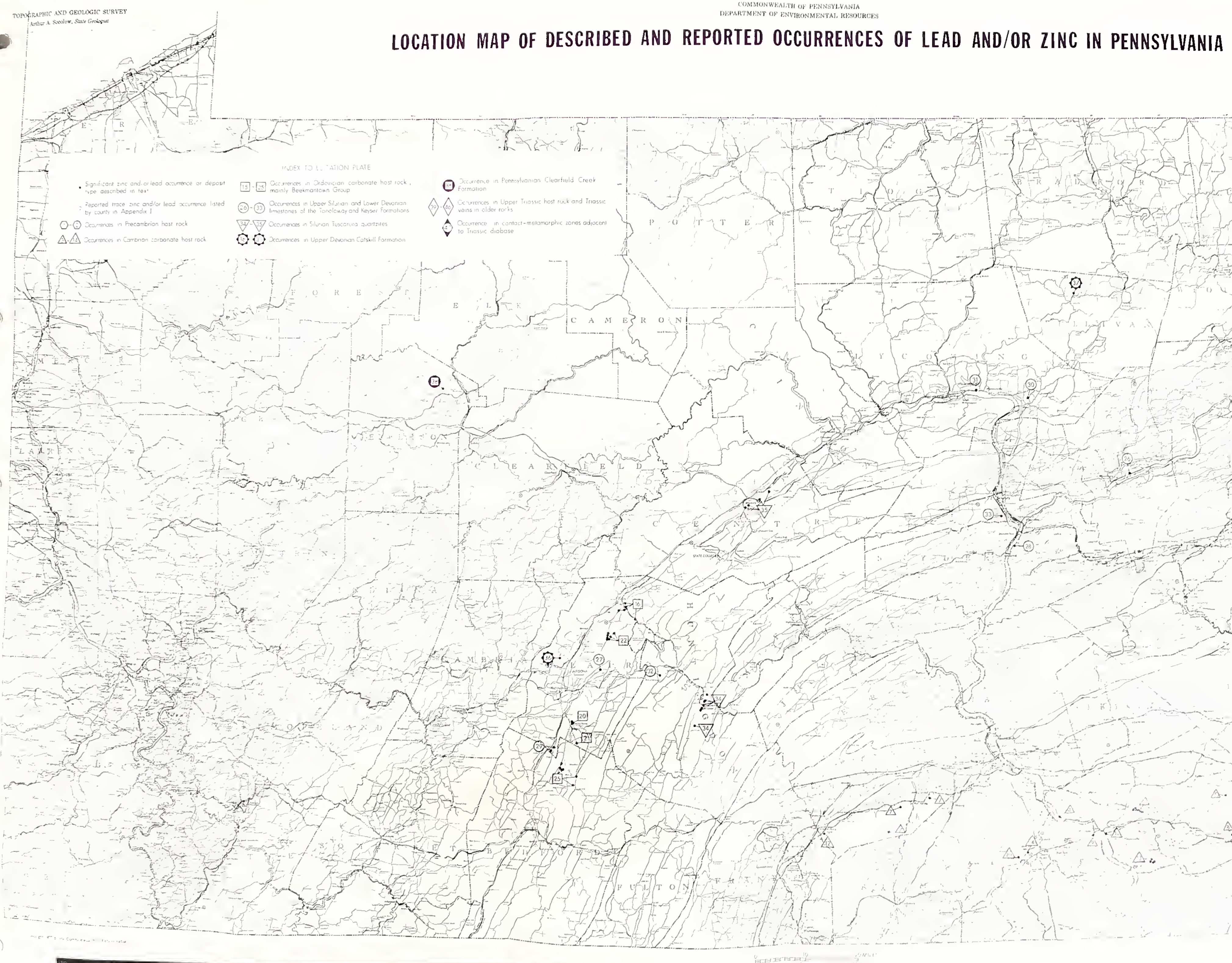
Figure 109. Data from diamond drill holes 2, 3, 4, and 5 at the S. Snyder Prospect area, Bedford Co. (Data courtesy of The New Jersey Zinc Co.)

INDEX

TOPOGRAPHIC AND GEOLOGIC SURVEY
Arthur A. Socolow, State Geologist

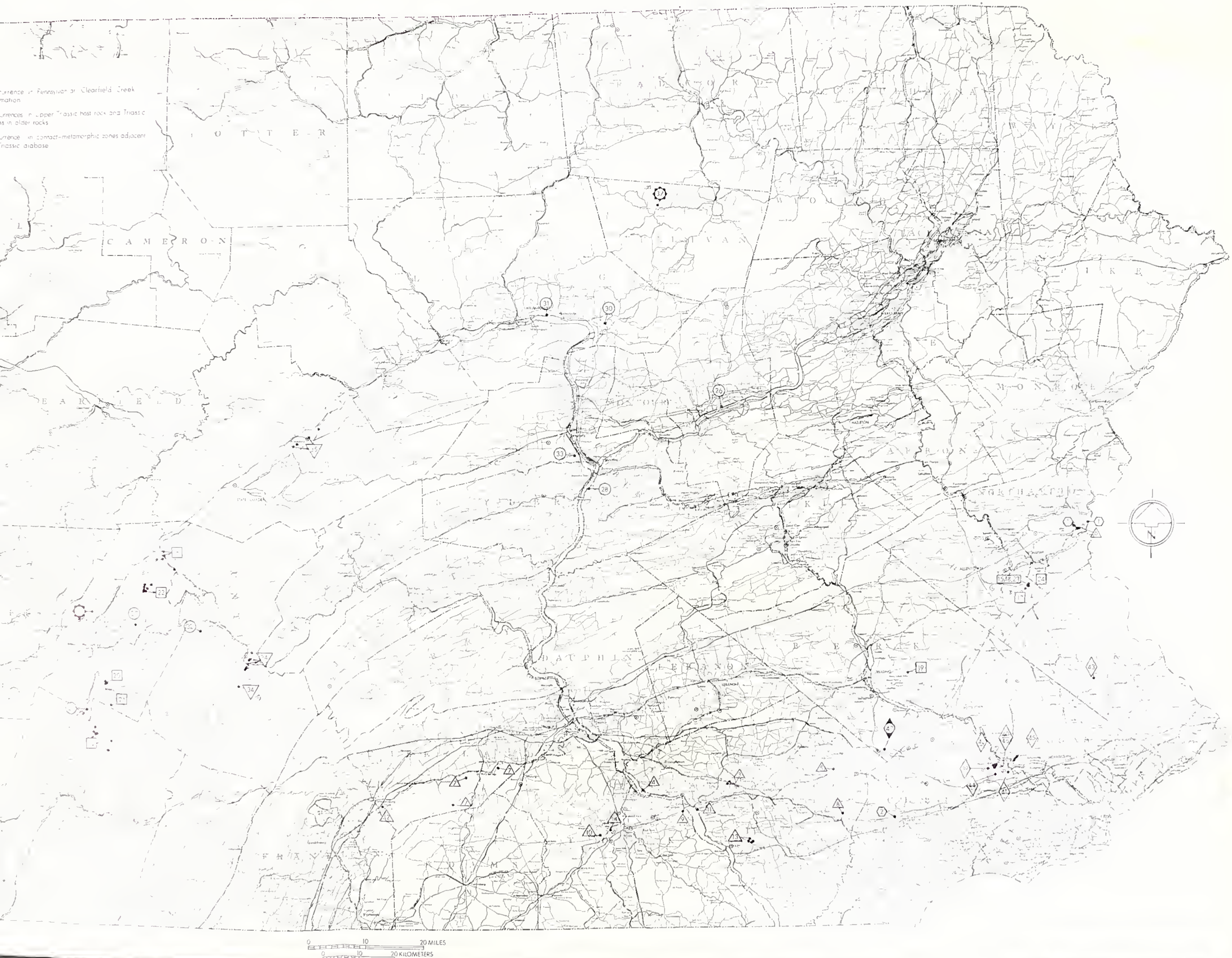
COMMONWEALTH OF PENNSYLVANIA
DEPARTMENT OF ENVIRONMENTAL RESOURCES

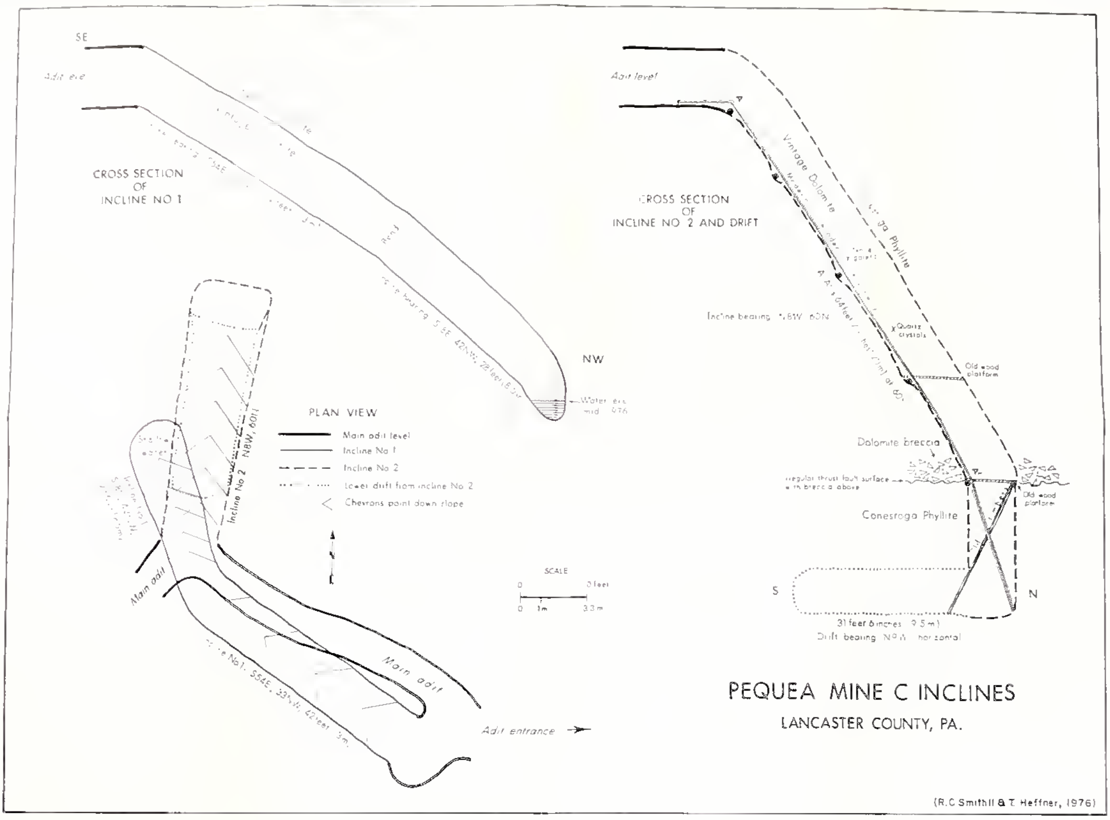
LOCATION MAP OF DESCRIBED AND REPORTED OCCURRENCES OF LEAD AND/OR ZINC IN PENNSYLVANIA

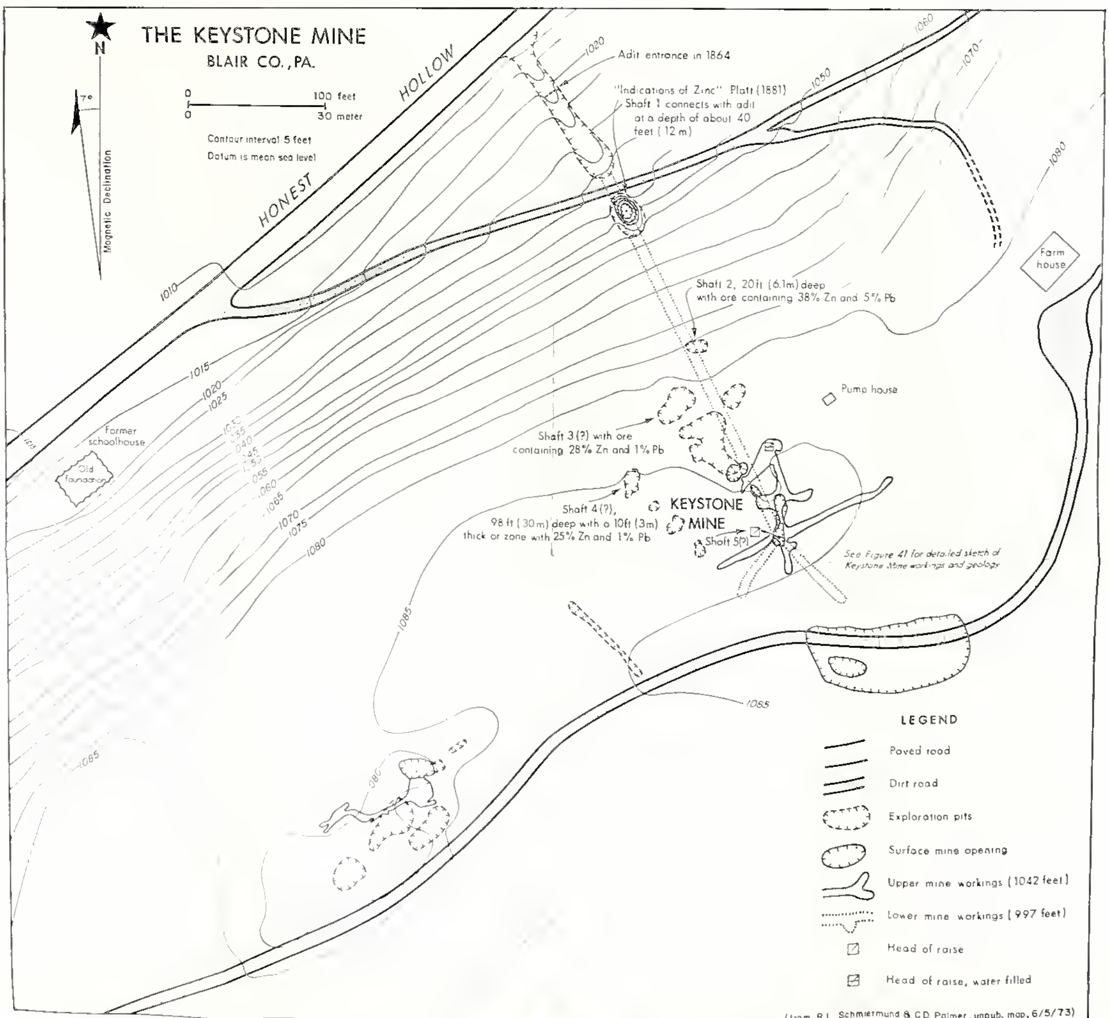


COMMONWEALTH OF PENNSYLVANIA
DEPARTMENT OF ENVIRONMENTAL RESOURCES

MAP OF DESCRIBED AND REPORTED OCCURRENCES OF LEAD AND/OR ZINC IN PENNSYLVANIA




PEQUEA MINE C INCLINES
LANCASTER COUNTY, PA.
CROSS SECTION OF INCLINE NO 1
CROSS SECTION OF INCLINE NO 2 AND DRIFT
PLAN VIEW
Main adit level
Incline No 1
Incline No 2
Lower drift from incline No 2
Chevrons point down slope
SCALE
Adit level
SE
NW
S
N
Dolomite breccia
Conestoga Phyllite
Old wood platform
Main adit
Adit entrance
Incline No 2
31 feet 6 inches (9.5 m)
(R.C Smith II & T. Heffner, 1976)

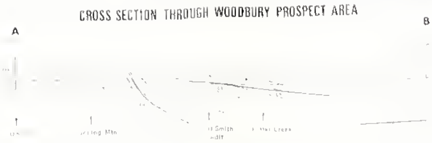

THE KEYSTONE MINE
BLAIR CO., PA.
N
100 feet
30 meter
Contour interval 5 feet
Datum is mean sea level
Magnetic Declination
HONEST HOLLOW
Adit entrance in 1864
"Indications of Zinc" Platt (1881)
Shaft 1 connects with adit at a depth of about 40 feet (12 m)
Shaft 2, 20 ft (6.1m) deep with ore containing 38% Zn and 5% Pb
Pump house
Farm house
Former schoolhouse
Old foundation
Shaft 3 (?) with ore containing 28% Zn and 1% Pb
Shaft 4 (?), 98 ft (30 m) deep with a 10ft (3m) thick ore zone with 25% Zn and 1% Pb
KEYSTONE MINE
Shaft 5(?)
See Figure 41 for detailed sketch of Keystone Mine workings and geology
LEGEND
Paved road
Dirt road
Exploration pits
Surface mine opening
Upper mine workings (1042 feet)
Lower mine workings (997 feet)
Head of raise
Head of raise, water filled
(from R.L. Schmiermund & C.D. Palmer, unpub. map, 6/5/73)

LEGEND

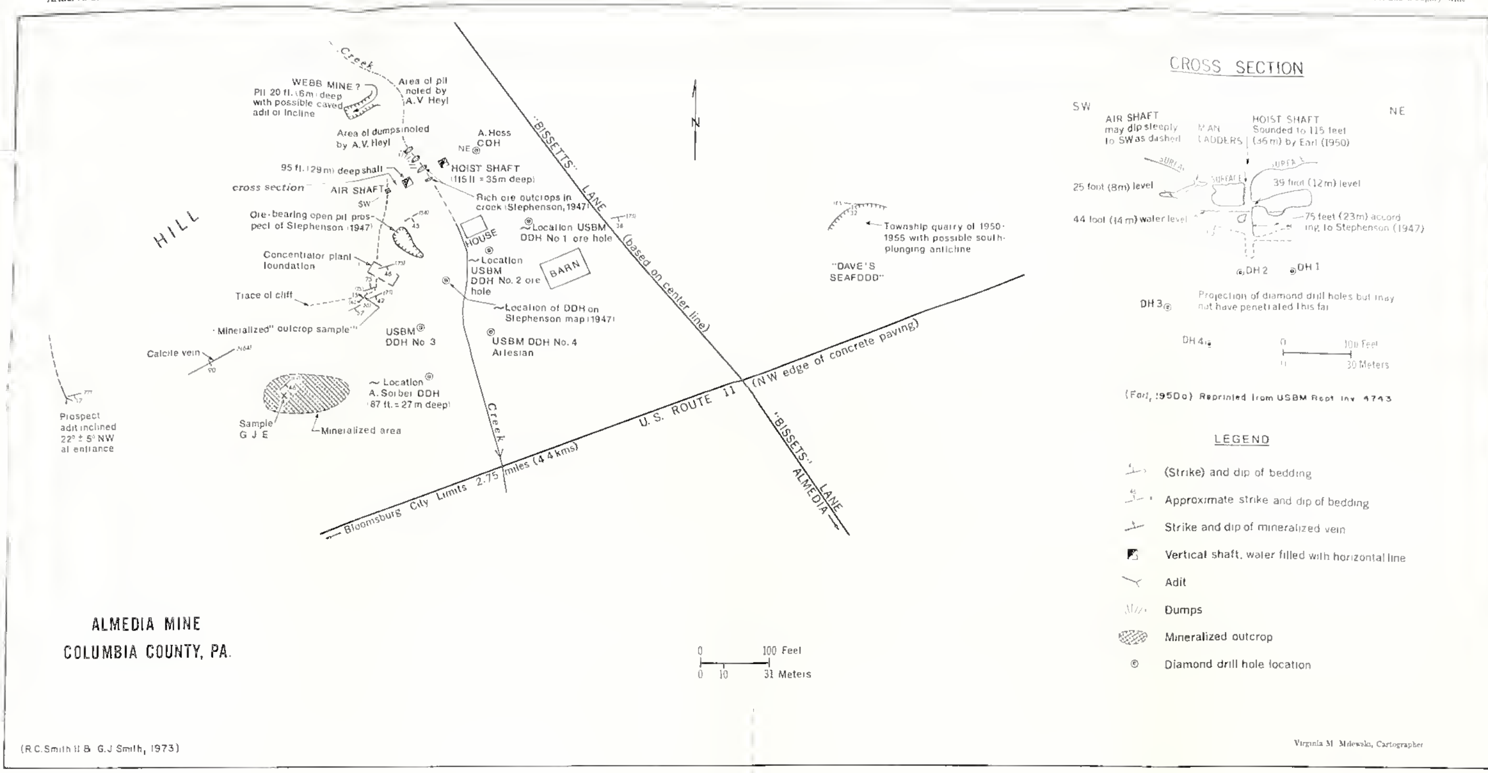
DEVONIAN — Keyser Fm limestone
Tonoloway Fm shaly limestone
Wills Creek Fm calcareous shale
Bloomsburg Fm red shale
Mifflintown Fm shale and limestone
Rose Hill Fm shale
Tuscarora Fm white quartzite
Juniata Fm red sandstone
Bald Eagle Fm sandstone
Reedsville Fm buff shale
Trenton Gp limestone
Loysburg Fm, Milroy Mbr limestone
Beekmantown Gp dolomites and limestones (possible ore hosts)
Bellefonte Fm dolomite
Axemann Fm limestone
Nittany Fm dolomite
Larke Fm dolomite
Gatesburg Fm sandy dolomite
Ore Hill Mbr limestone
Warrior Fm dolomite and limestone (possible ore hosts)

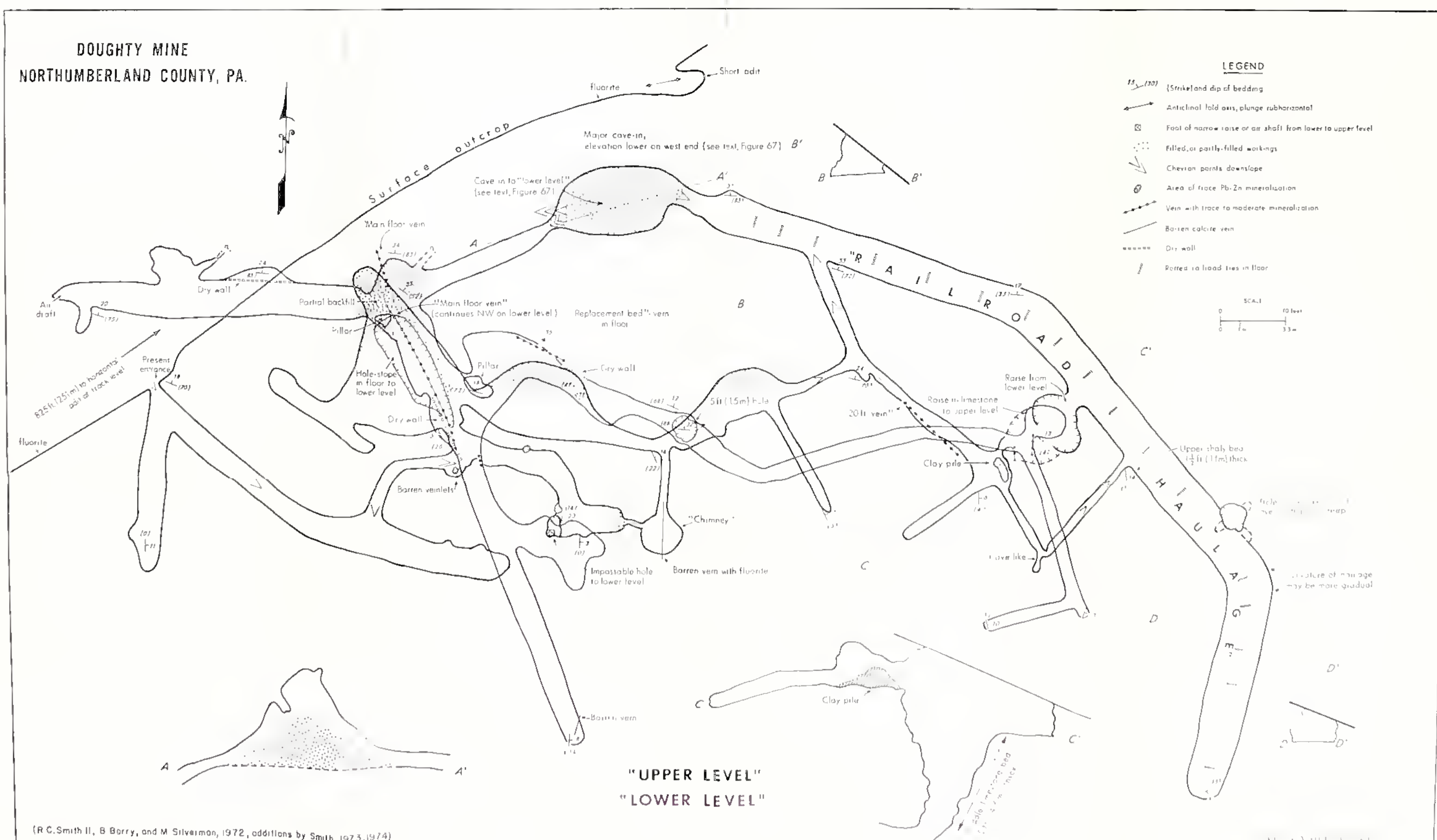
Approximate strike and dip of bed
Strike and dip of overturned bed
Strike of vertical bed
Thrust fault
Thrust fault and dip of fault plane
Stream sediment sample

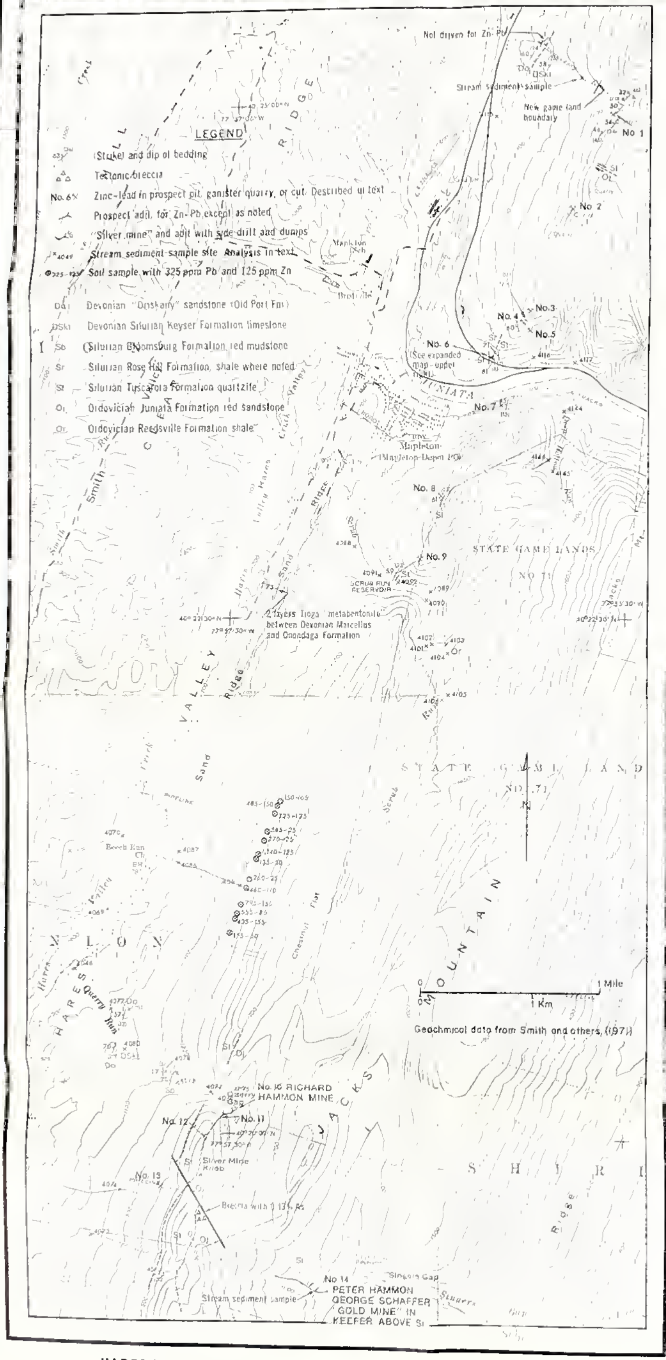
CROSS SECTION THROUGH WOODBURY PROSPECT AREA



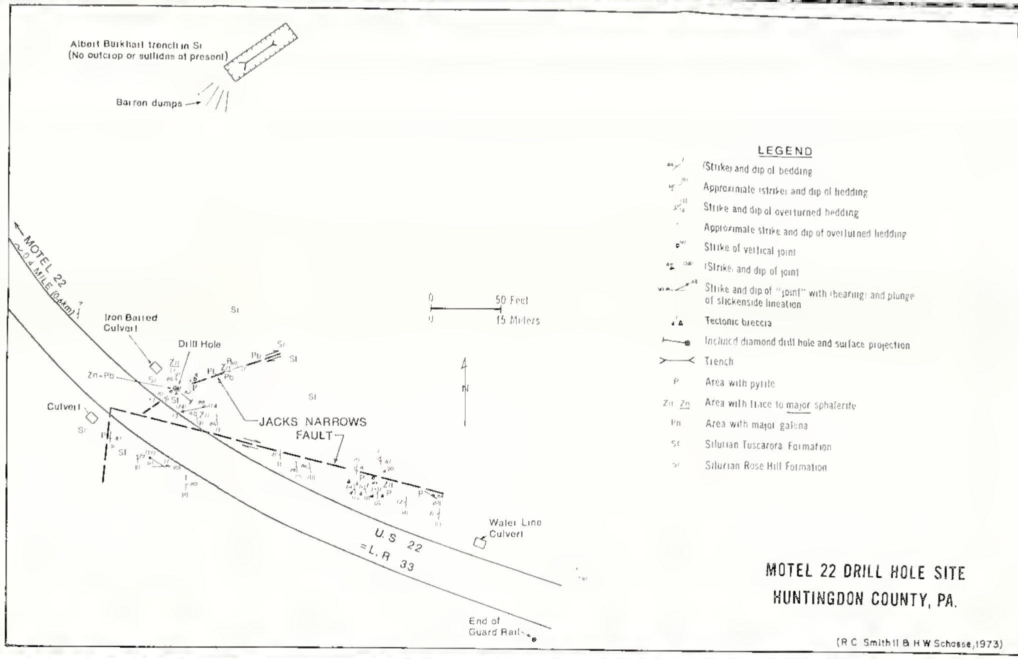
WOODBURY, ROARING SPRING AND SOISTER MINE PROSPECT AREA
BEDFORD AND BLAIR COUNTIES, PENNSYLVANIA

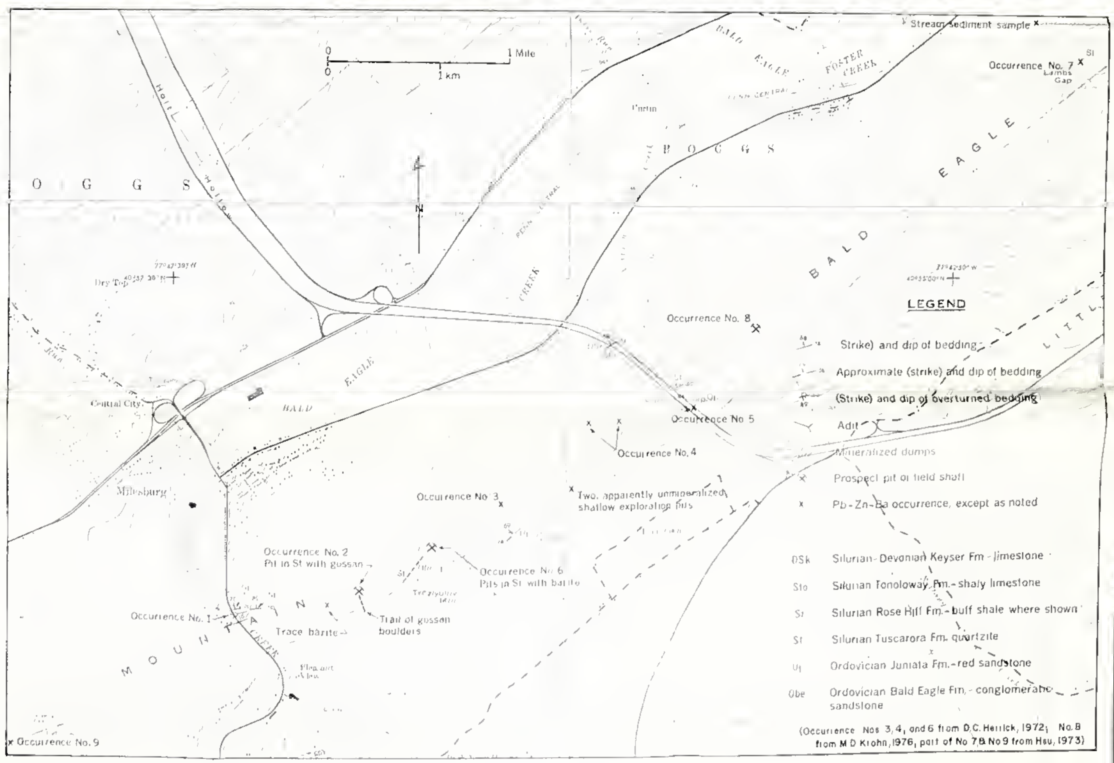

ALMEDIA MINE
COLUMBIA COUNTY, PA.
Creek
WEBB MINE ?
Pit 20 ft. (6m) deep with possible caved adit or incline
Area of pit noted by A.V. Heyl
Area of dumps noted by A.V. Heyl
A. Hoss COH
HOIST SHAFT (115 ft = 35m deep)
95 ft. (29m) deep shaft
cross section
AIR SHAFT
Rich ore outcrops in creek (Stephenson, 1947)
Ore-bearing open pit prospect of Stephenson (1947)
HILL
Concentrator plant foundation
Trace of cliff
"Mineralized" outcrop sample
Calcite vein
Prospect adit inclined 22° ± 5° NW at entrance
HOUSE
BARN
Location USBM DDH No 1 ore hole
Location USBM DDH No. 2 ore hole
Location of DDH on Stephenson map (1947)
USBM DDH No 3
USBM DDH No. 4 Artesian
Location A. Sorber DDH 87 ft. = 27 m deep
Sample G J E
Mineralized area
"BISSETTS" LANE (based on center line)
"BISSETTS" ALMEDIA LANE
U. S. ROUTE 11 (NW edge of concrete paving)
Bloomsburg City Limits 2.75 miles (4.4 kms)
Creek
N
Township quarry of 1950-1955 with possible south-plunging anticline
"DAVE'S SEAFOOD"
0 100 Feet
0 10 31 Meters
CROSS SECTION
SW
NE
AIR SHAFT may dip steeply to SW as dashed
MAN LADDERS
HOIST SHAFT Sounded to 115 feet (36 m) by Earl (1950)
25 foot (8m) level
39 foot (12m) level
44 foot (14 m) water level
75 feet (23m) according to Stephenson (1947)
DH 2
DH 1
DH 3
DH 4
Projection of diamond drill holes but may not have penetrated this far
0 100 Feet
30 Meters
(Earl, 1950a) Reprinted from USBM Rept Inv. 4743
LEGEND
(Strike) and dip of bedding
Approximate strike and dip of bedding
Strike and dip of mineralized vein
Vertical shaft, water filled with horizontal line
Adit
Dumps
Mineralized outcrop
Diamond drill hole location
(R.C.Smith II & G.J Smith, 1973)
Virginia M. Mdewski, Cartographer


DOUGHTY MINE
NORTHUMBERLAND COUNTY, PA.
Short adit
fluorite
Surface outcrop
Major cave-in, elevation lower on west end (see text, Figure 67)
Cave in to "lower level" (see text, Figure 67)
Main floor vein
Dry wall
Air draft
Portal backfill
"Main floor vein" (continues NW on lower level)
Replacement bed" vein in floor
Pillar
Present entrance
825 ft (251 m) to horizontal adit at track level
Hole-stope in floor to lower level
Dry wall
fluorite
Barren veinlets
Dry wall
5 ft (1.5m) hole
20 ft. vein
Raise in limestone to upper level
Raise from lower level
Clay pile
"Chimney"
Impassable hole to lower level
Barren vein with fluorite
"RAILROAD HAULAGE"
Upper shaly bed
Cave like
Barren vein
Clay pile
A
A'
B
B'
C
C'
D
D'
LEGEND
(Strike) and dip of bedding
Anticlinal fold axis, plunge subhorizontal
Foot of narrow raise or air shaft from lower to upper level
Filled, or partly-filled workings
Chevron points downslope
Area of trace Pb-Zn mineralization
Vein with trace to moderate mineralization
Barren calcite vein
Dry wall
Parted to hood ties in floor
SCALE
"UPPER LEVEL"
"LOWER LEVEL"
(R.C.Smith II, B Borry, and M Silverman, 1972, additions by Smith, 1973, 1974)



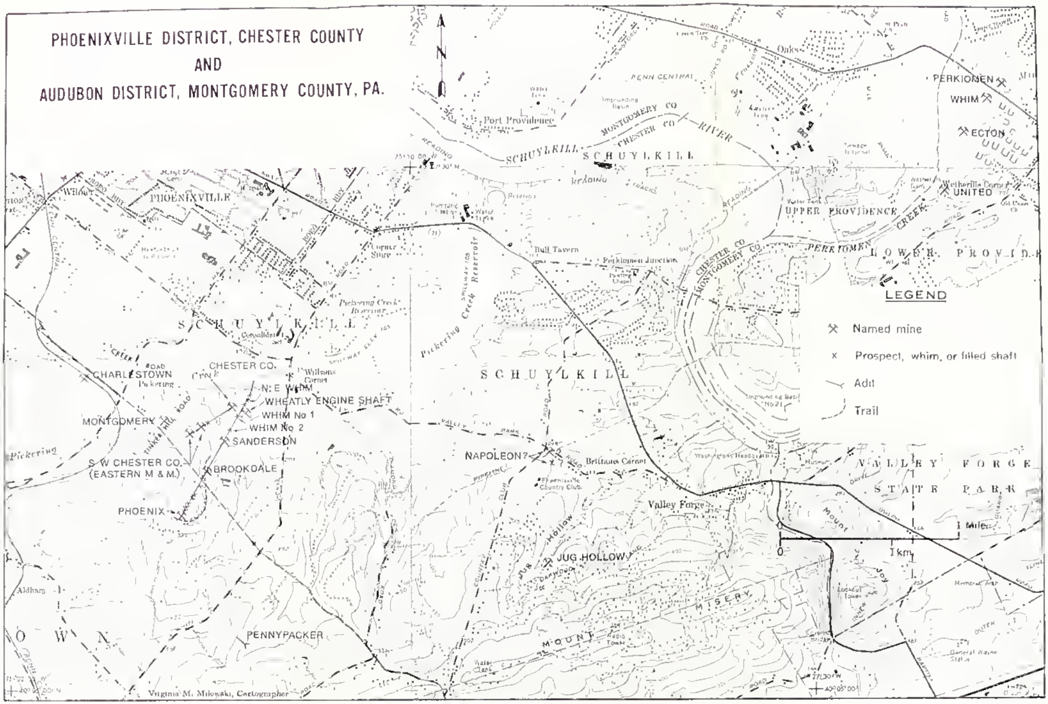
HARES VALLEY AREA
HUNTINGDON COUNTY, PA.

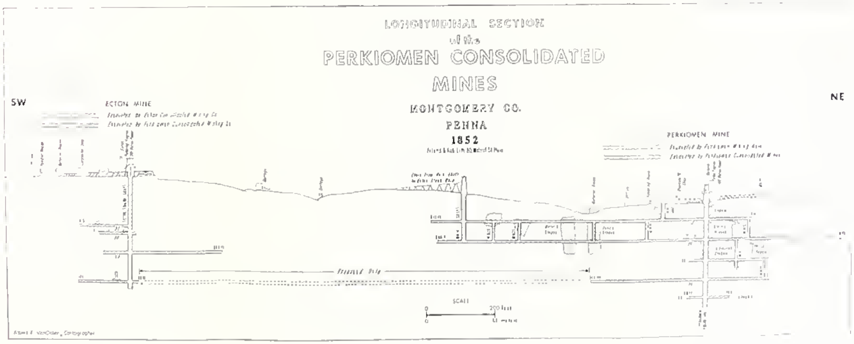


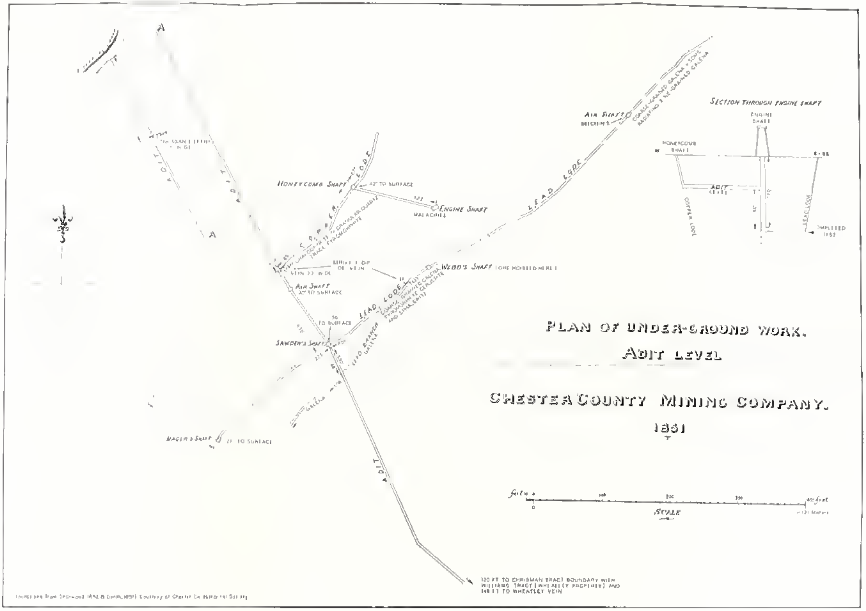


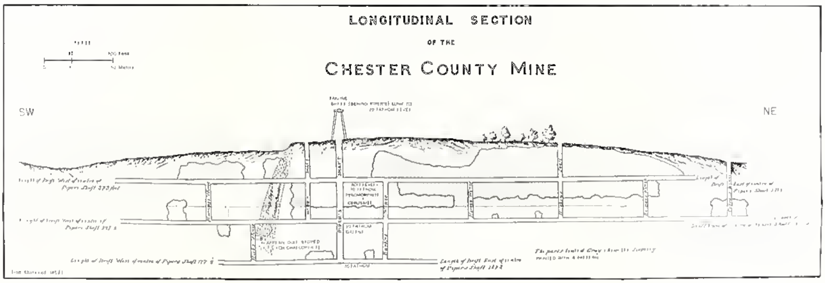
MILESBURG GAP AREA
CENTRE COUNTY, PA.

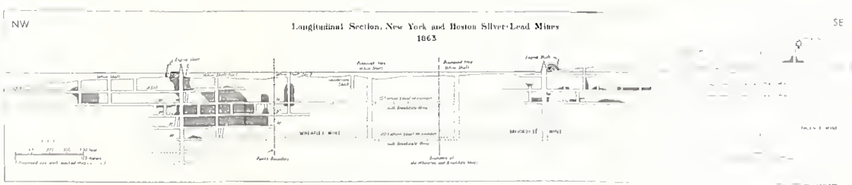
Virginia St. Milewski, Cartographer


PHOENIXVILLE DISTRICT, CHESTER COUNTY
AND
AUDUBON DISTRICT, MONTGOMERY COUNTY, PA.
N
LEGEND
Named mine
Prospect, whim, or filled shaft
Adit
Trail
PERKIOMEN
WHIM
ECTON
UNITED
PHOENIXVILLE
SCHUYLKILL
CHARLESTOWN
CHESTER CO.
N. E. WHIM
WHEATLY ENGINE SHAFT
WHIM No 1
WHIM No 2
SANDERSON
MONTGOMERY
S.W. CHESTER CO.
(EASTERN M. & M.)
BROOKDALE
PHOENIX
NAPOLEON?
JUG HOLLOW
PENNYPACKER
Port Providence
Oaks
Bull Tavern
Perkiomen Junction
Valley Forge
VALLEY FORGE
STATE PARK
UPPER PROVIDENCE
LOWER PROVID
MOUNT MISERY
1 Mile
0
1 km
Virginia M. Milewski, Cartographer

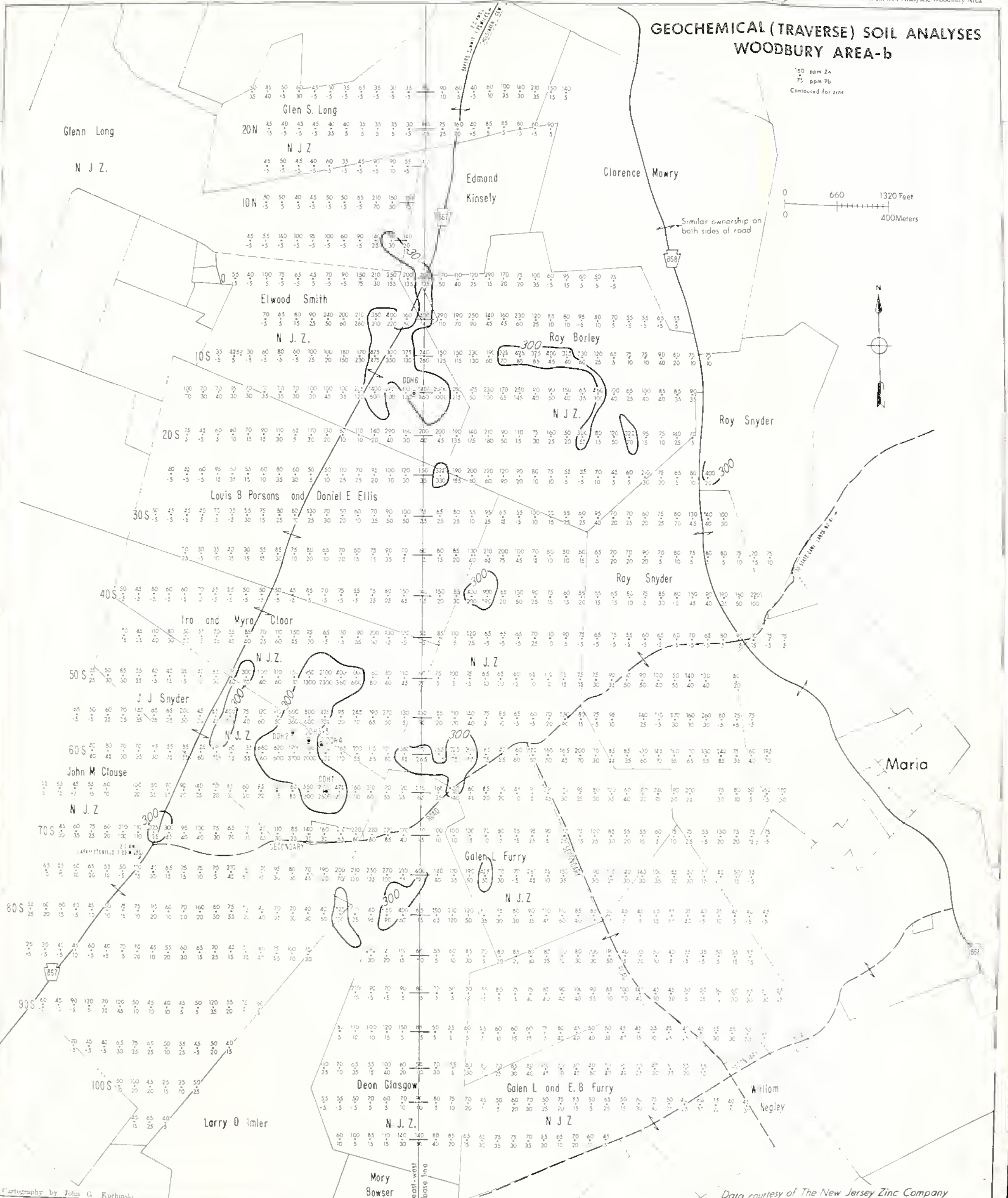

LONGITUDINAL SECTION
of the
PERKIOMEN CONSOLIDATED
MINES
MONTGOMERY CO.
PENNA
1852
SW
NE
ECTON MINE
PERKIOMEN MINE
SCALE







CROSS SECTIONS OF WHEATLEY, BROOKDALE AND PHOENIX MINES, CHESTER COUNTY, PA


GEOCHEMICAL (TRAVERSE) SOIL ANALYSES
WOODBURY AREA-b
160 ppm Zn
75 ppm Pb
Contoured for zinc
0 660 1320 Feet
0 400 Meters
Similar ownership on both sides of road
N
Glenn Long
N J Z.
Glen S. Long
20N
N J Z
Edmond Kinsely
Clorence Mowry
10N
Elwood Smith
N. J. Z.
Roy Borley
10 S
DDH6
N J Z.
Roy Snyder
20 S
Louis B Porsons and Doniel E Ellis
30 S
40 S
Roy Snyder
Iro and Myro Cloor
N J.Z.
N J Z
50 S
J J Snyder
N J. Z.
DDH2
DDH3
DDH4
60 S
DDH1
John M Clouse
Maria
N J Z
70 S
SECONDARY
ROAD
Galen L Furry
N J Z
80 S
90 S
100 S
Deon Glasgow
Galen L ond E.B Furry
William Negley
Larry D Imler
N J. Z.
N J Z
Mory Bowser
east-west base line
Cartography by John G. Kuchinski
Data courtesy of The New Jersey Zinc Company